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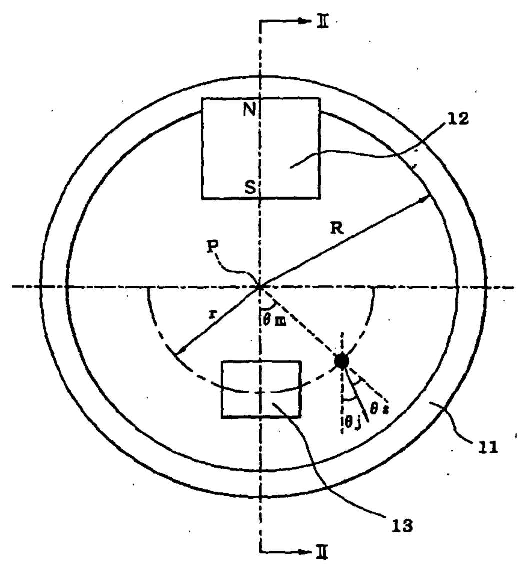
(54) Angular position transducer with offset magnetic transducer

(57) An angular position detecting apparatus using a magnetic detecting element, which can voluntary widely set an output change characteristic of the magnetic detecting element with respect to angular positions. The apparatus includes a cylindrical or elliptical yoke (11), and a magnet (12) fixed to a predetermined position in the cylindrical yoke. A magnetic detecting element (13), which is fixed to a rotor, is provided in a magnetic field generated between the magnet and the cylindrical yoke, so that a position of the magnetic detecting element is shifted from a rotation axis P of the rotor by a predetermined distance r. A ferromagnetic thin film magnetic resistance element applies a magnetic field which has intensity so that outputs from the elements are saturated. As a result, the magnetic detecting element generates outputs depending only on a magnetic flux detection angle θs independent of an influence of changes of magnetic field intensity due to temperature changes. In this case, when at least one of a rotation radius r of the magnetic detecting element and a radius R of the cylindrical yoke is voluntary determined, an output change characteristic of the magnetic detecting element can be voluntary set. Several magnetic detecting elements (13) are used to achieve a broad linear region. The region around zero is used for high accuracy. Application with a throttle valve.

FIG. 1



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[0001] This invention relates to angular position detecting apparatuses, and particular to an angular position detecting apparatus which detects an angular position of a target detection object by using a magnetic detecting element.

[0002] In this kind of angular position d t cting apparatus, an angular position detecting apparatus as shown in, for example, JP A 61-75213 (see FIG. 22), has been proposed. According to this angular position detecting apparatus, a cylindrical magnet 1 is magnetized so that magnetic field is formed in parallel therein. A magnetic detecting element 2 is positioned at a center portion of the magnet 1. The magnet 1 (parallel magnetic field) is rotated in response to a rotation of the target detection object. As a result, an amount of magnetic flux crossing the magnetic detecting element 2 is changed. An output signal from the magnetic detecting element 2 changes in proportion to the amount of the magnetic flux. The angular position θm of the target detection object is detected based on an the output signal from the magnetic detecting element 2.

[0003] In a case where the angular position θm of the target detection object is detected based on the output signal from the magnetic detecting element 2 like this, when a detectable range of the angular position θm is expanded, an output change characteristic of the magnetic detecting element 2 with respect to the angular position θm needs to be linearly changed within wider range as much as possible.

[0004] However, according to the conventional structure, since the parallel magnetic field is rotated with respect to the magnetic detecting element 2, the amount of magnetic flux crossing the magnetic detecting element 2 decreases based on a trigonometric function. As a result, the output change characteristic of the magnetic detecting element 2 with respect to the angular position θm deviates from a line, and curves based on the trigonometric function (see FIG. 8A). As a result, according to the conventional structure, a semi-linear output can be obtained within only a narrow range of the angular position θm. Therefore, the output change characteristic of the magnetic detecting element 2 with respect to the angular position θm becomes bad, and the detectable range of the angular position θm becomes narrow.

[0005] This invention has been conceived in view of the background thus far described and its object is to provide an angular position detecting apparatus which can optionally determine an output change characteristic of the magnetic detecting element with respect to the angular position within a wide range and which can improve a detection charac t ristic of the angular position.

[0006] According to a first aspect of the present invention, magnetic field is generated between a magnet and a yoke, and a magnetic detecting element is provided in the magnetic field. Here, the magnetic detecting element is offset from a rotation axis of a rotor. In this case, a relationship between an angle of magnetic flux crossing the magnetic detecting element and angular position of the rotor is changed. By using this change, an output change characteristic of the magnetic detecting element with respect to the angular position can be voluntary widely set. As a result, a detection characteristic of the angular position can be improved.

[0007] According to a second aspect of the present invention, each of the magnetic detecting elements has a range of an angular position in which an output characteristic becomes linear. The range is different from each other with respect to every magnetic detecting element. An output selector selectively generates outputs of a particular magnetic detecting element in a linear region, depending on the angular position. As a result, a detectable angle range, in which an output change characteristic of the angular position detecting apparatus becomes linear, can be considerably expanded compared to a case where the magnetic detecting element is only one.

[0008] According to a third aspect of the present invention, a magnet and a magnetic detecting element are arranged so that outputs of the magnetic detecting element becomes substantially zero at around a particular angular position at which detection accuracy is extremely required. Incidentally, according to the angular position apparatus using the magnetic detecting element, detection accuracy is best at a point where the output of the magnetic detecting element becomes zero. This is because the point where the output of the magnetic detecting element becomes zero is the center of the linear region of the outputs, and therefore the linearity becomes the best. Furthermore, when the output of the magnetic detection is zero, influence to the magnetic detecting element due to a thermal characteristic becomes small. Therefore, influence to the magnetic detecting element due to a thermal characteristic becomes small at around a particular angular position at which detection accuracy is extremely required. As a result, a detection characteristic of the angular position can be improved.

[0009] These and another objects, features and characteristics of the present invention will be appreciated from a study of the following detailed description, the appended claims, and drawings, all of which form parts of this application. In the drawings, same portions or corresponding portions are put the same numerals each other to eliminate r dundant explanation. In the drawings:

FIG. 1 is a plan view illustrating a main portion of an angular position detecting apparatus of a first embodiment according to the present invention;

FIG. 2 is a vertical sectional view taken along a line II-II in FIG. 1;

FIG. 3 is a circuit configuration of a magnetic detecting element;

FIG. 4 is a diagram illustrating a relationship b tw en an angle θs of magnetic flux crossing the magnetic detecting element and a magnetic flux detecting element;
FIG. 5 is a diagram illustrating a relationship among a rotor angular position θm, a magnetic field angle θj, and a magnetic flux detection angle θs;
FIG. 6 is a diagram illustrating a change charact ristic of the magnetic field angle θj with respect to the rotor angular position θm;
FIG. 7 is a diagram illustrating a change characteristic of the magnetic flux detection angle θs with respect to the rotor angular position θm;
FIG. 8A is an output waveform of a conventional magnetic detecting element;
FIG. 8B is an output waveform of a magnetic detecting element of this embodiment;
FIG. 9 is a diagram illustrating a difference between a magnetic field conversion of this embodiment and a simple proportional conversion;
FIG. 10 is a diagram illustrating a reason of improving a linearity of output from the magnetic detecting element as a result of magnetic field conversion of this embodiment;
FIG. 11 is a diagram illustrating a relationship between a rotational radius r of the magnetic detecting element and a change characteristic of the magnetic flux detection angle θs;
FIG. 12 is a diagram illustrating a relationship between a rotational radius r of the magnetic detecting element and an output change characteristic of the magnetic detecting element;
FIG. 13A is a plan view illustrating a main portion of an angular position detecting apparatus of a second embodiment according to the present invention;
FIG. 13B is a vertical sectional view taken along a line XIIIB-XIIIB in FIG. 13A;
FIG. 14A is a plan view illustrating a main portion of an angular position detecting apparatus of a third embodiment according to the present invention;
FIG. 14B is a vertical sectional view taken along a line XIVB-XIVB in FIG. 14A;
FIG. 15A is a plan view illustrating a main portion of an angular position detecting apparatus of a fourth embodiment according to the present invention;
FIG. 15B is a vertical sectional view taken along a line XVB-XVB in FIG. 15A;
FIG. 16 is a vertical sectional view illustrating a main portion of an angular position detecting apparatus of a fifth embodiment according to the present invention;
FIG. 17 is a vertical sectional view illustrating an angular position detecting apparatus of a sixth embodiment according to the present invention;
FIG. 18 is a vertical sectional view taken along a line XVIII-XVIII in FIG. 17, when a magnet and a cylindrical yoke are rotated to a clockwise with respect to a substrate;
FIG. 19 is a vertical sectional view taken along the line XVIII-XVIII in FIG. 17, when the magnet and the cylindrical yoke are rotated to a counterclockwise with respect to the substrate;
FIG. 20 is a vertical sectional view taken along the line XX-XX in FIG. 17;
FIG. 21 is a vertical sectional view illustrating an angular position detecting apparatus of a seventh embodiment according to the present invention;
FIG. 22 is a plan view illustrating a conventional angular position detecting apparatus;
FIG. 23 is a vertical sectional view illustrating an angular position detecting apparatus of an eighth embodiment according to the present invention;
FIG. 24 is a plan view illustrating a relationship of arrangements of the yoke, the magnet, and the magnetic detecting element of the eighth embodiment;
FIG. 25 is a plan view illustrating a relationship of arrangements of the yoke, the magnet, and the magnetic detecting element of a ninth embodiment;
FIG. 26 is a vertical sectional view taken along the line XXVI-XXVI in FIG. 25;
FIG. 27 is a block diagram illustrating a process circuit for the output of two magnetic detecting elements of the ninth embodiment;
FIG. 28 is an output waveform of the two magnetic detecting elements of the ninth embodiment;
FIG. 29 is an output waveform of two amplifiers of the ninth embodiment;
FIG. 30 is an output waveform of two offset circuits of the ninth embodiment;
FIG. 31 is a final output waveform of the magnetic detecting apparatus of the ninth embodiment;
FIG. 32 is a plan view illustrating a relationship of arrangements of the yoke, the magnet, and the magnetic detecting element of a tenth embodiment;
FIG. 33 is a block diagram illustrating a process circuit for the output of the magnetic detecting element of the tenth embodiment;
FIG. 34 is an output waveform of the magnetic detecting element of the tenth embodiment;
FIG. 35 is an output waveform an amplifier of the tenth embodiment; and

FIG. 36 is a final output waveform of the magnetic detecting apparatus of the tenth embodiment.

[0010] Hereinafter, a first embodiment of the present invention will be explained with reference to FIGS. 1 to 12. At first, a structure of an angular position detecting apparatus will be explained with reference to FIG. 1. A yoke 11 is made of a magnetic material such as a Permalloy or an iron, and is form d in a cylindrical shape. At a predetermined position at inner side of the cylindrical yoke 11, a magnet 12 such as a ferrite magnet is fixed. The magnet 12 is magnetized along a radial direction of the cylindrical yoke 11 such that an S-pole is arranged toward a center P of the cylindrical yoke 11, and an N-pole is contacted with the cylindrical yoke 11. Here, positions of the S-pole and N-pole of the magnet 12 may be arranged opposite position from that of FIG. 1. A thickness of the magnet 12 is set thinner than an internal diameter R of the cylindrical yoke 11. A sufficient space (not-shown) is secured between the magnet 12 and the center P of the cylindrical yoke 11. The magnet 12 and the cylindrical yoke 11 are fixed at a non-rotation portion (not-shown) of the housing or the like. The cylindrical yoke 11 is concentrically arranged with respect to a rotor (not-shown) that is connected to a target detection object.

[0011] A magnetic detecting element 13, which is fixed to the rotor, is arranged in magnetic field that is generated between the magnet 12 and the cylindrical yoke 11. The position of the magnetic detecting element 13 is arranged at a distance of a predetermined distance r from a rotation axis P (a center of the cylindrical yoke 11). The magnetic detecting element 13 is constructed by a bridge circuit of ferromagnetic thin film magnetic resistance elements 13a, as shown in FIG. 3. Magnetic field, which has intensity so that outputs from the elements 13 are saturated, is applied to the magnetic detecting element 13. As a result, the magnetic detecting element 13 generates outputs depending only on a magnetic flux detection angle θs independent of intensity of the magnetic field, as shown in FIG. 4.

[0012] Here, the magnetic detecting element 13 is not limited to the ferromagnetic thin film magnetic resistance element, and may use a magnetic detecting element that generates outputs in proportion to magnetic field intensity from one direction, such as a Hall element or a semiconductor magnetic resistance element. These elements cannot directly detect the magnetic flux different from the ferromagnetic thin film magnetic resistance elements. Therefore, when this kind of element is used, two elements may be perpendicularly arranged with each other so as to calculate an angle of the magnetic flux based on a ratio of outputs from each element.

[0013] Next, a distribution of the magnetic flux that is generated between the magnet 12 and the cylindrical yoke 11 will be explained. The magnetic flux from one pole (S-pole) of the magnet 12 is spread toward the cylindrical yoke 11. The magnet 12 is arranged far from the rotation axis P of the rotor (center of the cylindrical yoke 11). Therefore, as shown in FIG. 5, a magnetic field angle θj of a rotational locus (circumference whose center is the rotation axis P and whose diameter is r) of the magnetic detecting element 13 becomes smaller than the rotor angular position θm. FIG. 6 shows a diagram illustrating a relationship between the rotor angular position θm and the magnetic field angle θ j. Hereinafter, it is assumed that the rotor angular position θm at a position on a line connecting a center of the magnet 12 with the rotation axis P is 0 degree.

[0014] When the rotor is rotated, the magnetic detecting element 13 is rotated along a circumference whose center corresponds to the rotation axis P of the rotor and whose radius is r. Next, an output change characteristic of the magnetic detecting element 13 will be explained. In a case where the magnetic detecting element 13 is the ferromagnetic thin film magnetic resistance element, the magnetic detecting element 13 outputs in proportion to sin2 θs in accordance with the magnetic flux detection angle θs. When the magnetic detecting element 13 is rotated on the circumference of radius r, a direction of the magnetic detecting element 13 is also rotated by the angular position θm in proportion to the rotation of the angular position θm. As a result, a magnetic flux angular position θs, which is actually detected by th magnetic detecting element 13, is represented by (θm- θj), that is, subtraction of the magnetic field angle θj from the angular position θm of the magnetic detecting element 13. As a result, a relationship between the rotor angular position θm and the magnetic detection angle θs is shown as FIG. 7. As shown in FIG. 7, the magnetic detection angle θm becomes smaller than the rotor rotation angle θm. This is a first point for improving a linearity of output from the magnetic detecting element 13. Here, in the embodiment as shown in FIGS. 6 and 7, the rotor angler position θ m, the magnetic field angle θj, and the magnetic flux detection angle θs have the following relation.

ROTOR ANGULAR POSITION θm > MAGNETIC FIELD ANGLE θj > MAGNETIC FLUX DETECTION ANGLE θs

[0015] As described in the above, the output from the magnetic detecting element 13 is proportionate to sin2 θs . As shown in FIG. 4, when the magnetic flux detection angle θs is 0 degree, an output amplitude of the magnetic flux detecting element 13 becomes 0. Within a range of 0 degree < θs < 45 degree, the output amplitude of the magnetic flux detecting element 13 gradually increases as the magnetic flux detection angle θs increases. The output amplitude of the magnetic flux detecting element 13 becomes maximum at the magnetic flux detection angle θs is 45 degree.

[0016] According to the conventional structure shown in FIG. 22, the rotor rotation angle θm is equal to the magnetic flux detection angle θs, and the output from the magnetic flux detecting el ment 13 is a curve proportion to a trigonometric function (sin2 θm). Therefore, as shown in FIG. 8A, a semi-linear output can be obtained only a narrow

range of the rotor angular position θm. As a result, the output change characteristic of the magnetic detecting element 2 with respect to the rotor angular position θm becomes bad and the detectable angle range of the rotor angular position θm becomes narrow.

[0017] On the contrary, according to this embodiment, as described in the above, the magnetic flux detection angle θs becomes smaller than the rotor angular position θm (first point), and the linearity of a wave form itself of the magnetic detecting element 13 can be improved as described later (second point). Therefore, the linearity of the output from the magnetic detecting element 13 can be secured within considerably wide range (see FIG. 8A).

[0018] Next, an improvement of the linearity of the output waveform, which is the second point for improving the linearity of the output from the magnetic detecting element 13, will be explained.

[0019] It is assumed that the magnetic flux detection angle θs and the rotor angular position θm have a relationship of $\theta s = \theta m/3$ (see FIG. 9), the output from the magnetic detecting element 13 becomes a trigonometric function proportionate to $\sin(2 \cdot \theta m/3)$. This structure can expand the detectable angle range of the rotor angular position θ m, however, the structure can output only the semi-linear output. Therefore, it cannot say that this structure improves the linearity of the outputs.

[0020] On the contrary, according to this embodiment, as shown in FIG. 9, the relationship between the magnetic flux detection angle θ s and the rotor angular position θm is not simple proportional relation shown as A, but is a non-linearity relationship shown as B. That is, when the rotor angular position θm is small, a conversion rate of the magnetic flux detection angle θs is large; whereas when the rotor angular position θm is large, the conversion rate of the magnetic flux detection angle θs is small. A reason of this is as follows. As shown in FIG. 5, magnetic field occurs between the magnet 12 and the cylindrical yoke 11 does not spread uniformly, but changes in accordance with the rotor angular position θm. An amount of changing of the magnetic field angle θj is firstly small in accordance with the rotor angular position, and is gradually increased as it approaches θm=90 degree. As a result, when the rotor angular position θm is small, the conversion rate of the magnetic flux detection angle θs (= rotor angular position θm - magnetic field angular θj) is large, and the conversion rate of the magnetic flux detection angle θs becomes small as the rotor angular position θm increases. This leads to improvement of the linearity of the output of the magnetic detecting element 13.

[0021] Specifically, as shown in FIG. 10, since the conventional output is represented by the trigonometric function, an inclination of a linear region A is large, and inclinations of linear regions B and C gradually decrease as the rotor angular position θm becomes further apart. On the contrary, according to this embodiment, within a linear region A', the magnetic flux detection angle θs changes so that an inclination of the output becomes smaller than that of the conventional output. Furthermore, within regions B' and C' at both sides of the linear region A', the magnetic flux detection angle θs changes so that each of the inclinations of the outputs becomes larger than that of the conventional outputs. As a result, the regions B' and C' positioned at both sides of the linear region A' also becomes linear regions that continues to the linear region A', and therefore the linearity of the output from the magnetic detecting element 13 can be secured at considerably wide range, and the detectable angle range of the rotor angular position θ m can be considerably expanded compared to the conventional one.

[0022] Incidentally, the relationship between the rotor angular position θm and the magnetic flux detection angular θs changes based on the rotational radius r of the magnetic detection sensor 13 (an amount of shift r from the rotation axis P), as shown in FIG. 11. Specifically, the larger the rotational radius r of the magnetic detecting element 13 becomes, the smaller the magnetic flux detection angle θs becomes. Since the output from the magnetic detecting element 13 becomes large in accordance with the change, when the radius r of the magnetic detecting element 13 changes, the output from the magnetic detecting element 13 also changes. Therefore, as shown in FIG. 12, the output change characteristic of the magnetic detecting element 13 can be changed by changing the rotational radius r of the magnetic detecting element 13. Thus, the output change characteristic can become linear, and can also be set to a curve having an upper convex or a curve having a lower convex.

[0023] Furthermore, the relationship between the rotor angular position θm and magnetic flux detection angle θs also changes based on the radius R of the cylindrical yoke 11 as well as the rotational radius r of the magnetic detecting element 13. Therefore, when one of the rotational radius r of the magnetic detecting element 13 and the radius R of the cylindrical yoke 11 is optionally determined, the output change characteristic of the magnetic detecting element 13 can optionally determined to any one of the linear, the curve having upper convex, or the curve having lower convex.

[0024] Here, the cylindrical yoke 11 is applied in the first embodiment, however, a shape of the yoke may be changed to an ellipse shape by arranging a ratio of internal radiuses X and Y such as yokes 14 and 15 shown in FIGS. 13 and 14 as a second and a third embodiment, respectively. Furthermore, the shape of the yoke 16 may be changed to a circular arc (one part of a cylinder) or to an ellipse arc (one part of an ellipse cylinder), as shown in FIG. 15 as a fourth embodiment. In short, an internal surface of the yoke is set to a curved surface having a gentle radius of curvature, so that magnetic filed distribution is gradually changed in proportion to the rotor angular position θm. Here, in the embodiment as shown in FIG. 15, one pole of the magnet 12 is fixed to a magnetic circuit formation member 17 that is provided at th yoke 16, and another pole of the magnet 12 is confronted with the center position of the yok 16.

[0025] Furthermore, in the above embodiment, the center of the yoke and the rotation axis of the magnetic detect-

ing element 13 (rotation axis) are matched each other, however, these are not needed to be matched. Her , it is preferable to arrange so that the one pole of the magnet 12 is positioned toward the center portion of the yoke. As a result, the magnetic field distribution (direction and intensity) occurring between the magnet 12 and the yoke can be symmetrical with respect to the center line connecting the magnet 12 and the center of the yoke.

[0026] Moreover, in ach of th mbodiments, th magnetic detecting element 13 does not n ed to be arranged at the inner space of the yoke. As shown in FIG. 16 as a fifth embodiment, the magnetic detecting element 13 may be arranged around front portion of the yoke 18 or around rear portion thereof. In short, the magnetic detecting element 13 may be arranged anywhere as long as it is arranged in the magnetic field generated between the magnet 12 and the yoke 18.

[0027] In general, when temperature of the magnet 12 changes, magnetic field intensity changes without changing the magnetic flux angle θs. However, when the output from the magnetic detecting element is changed as a result of changing of the magnetic field intensity due to the temperature changes, detection value of the magnetic flux angle θs causes error. In such a case, it needs to correct the change of the magnetic field intensity due to the temperature change of the magnet 12.

[0028] Therefore, according to each of the embodiments, it is preferable to apply magnetic field having intensity so that the output saturates, by using the ferromagnetic thin film magnetic resistance element as the magnetic detecting element 13. When magnetic field having intensity so that the output saturates is applied, the ferromagnetic thin film magnetic resistance element generates outputs depending only the magnetic flux angle θs, independent of the magnetic field intensity. Therefore, even if the magnetic field intensity is changed due to the temperature changes of the magnet 12, the magnetic flux angle θs can be accurately directly detected without causing an influence of the change in the magnetic field intensity. Hence, it does not need to correct the change of the magnetic field intensity due to the temperature change of the magnet 12.

[0029] However, in the present invention, a magnetic detecting element that generates outputs in proportion to magnetic field intensity from one direction, such as a Hall element or a semiconductor magnetic resistance element, may be used. These elements cannot directly detect the magnetic flux different from the ferromagnetic thin film magnetic resistance elements. Therefore, when one element is used, two elements may be perpendicularly arranged with each other so as to calculate an angle of the magnetic flux based on a ratio of outputs from each element.

[0030] Furthermore, in each embodiment, the magnetic detecting element is rotated by fixing to the rotor; however, the yoke and the magnet may be rotated by fixing to the rotor.

[0031] Next, a sixth embodiment in which the present invention is further specified will be explained with reference to FIGS. 17 to 20. A rotation shaft 22 (rotor) of a target detection object such as a throttle valve is rotatably supported to a main housing 21 of an angular position detecting apparatus via a bearing. A cylindrical yoke 24 having a cup shape is fixed to a tip portion (right edge portion) of the rotation shaft 22 by using swaging or the like. At a predetermined position of an inside portion of the cylindrical yoke 24, a magnet 25 such as ferrite magnet is fixed by using resin mold or the like. The magnet 25 is magnetized along a radial direction of the cylindrical yoke 24, such that an S-pole is positioned toward a center portion of the cylindrical yoke 24 and an N-pole is contacted with the cylindrical yoke 24. Here, positions of the S-pole and N-pole of the magnet 25 may be exchanged therebetween.

[0032] Plural through holes for preventing short-circuit of the magnetic flux are provided to a left side portion of the cylindrical yoke 24 so as to surround the rotation shaft 22 (see FIG. 20). An outer side portion of the cylindrical yoke 24 is molded by a resin 27.

[0033] A connector housing 28 is assembled to a right side portion of the main housing 21 so as to cover an opening of the cylindrical yoke 24. A substrate 29 for wiring is fixed to an inner side of the connector housing 28 by resin molding of a substrate-fixing portion 31 (FIG. 18) or by swaging. For example two magnetic detecting elements 30 are mounted on the substrate 29. Each of he magnetic detecting elements 30 is arranged on a circumference of radius r whose center is the rotation axis of the cylindrical yoke 24 with an angular pitch of, for example, 90 degree. Each of he magnetic detecting elements 30 is arranged in the magnetic field generated between the magnet 25 and the cylindrical yoke 24. Similar to the above embodiment, each of the magnetic detecting elements 30 is selected from the ferromagnetic thin film magnetic resistance element, and magnetic field having intensity so that the output of this element saturates is applied thereto. As a result, each of the magnetic detecting elements 3o generates outputs similar to the trigonometric function depending on only the magnetic flux detection angle θs independent of the intensity of the magnetic field. When two magnetic detecting elements 30 are applied like this case, the rotor angular position θm can be detected with ascertaining whether there is abnormality or not by comparing the magnetic flux angles θs detected by two magnetic detecting elements 30. An input/output terminal of each magnetic detecting element 30 is connected to a terminal 32 in the connector housing 28 via a wire pattern of the substrate 29.

[0034] Here, FIG. 18 shows an example in which the magnet 25 and the cylindrical yoke 24 are rotated toward a clockwise direction; and FIG. 19 shows an example in which the magnet 25 and the cylindrical yoke 24 are rotated toward a counterclockwise direction. In each of these cases, the substrate 29 has a notch at a portion corresponding to a rotation range of the magnet 25 so that the magnet 25 does not touch the substrat 29.

[0035] According to the sixth embodiment in the above, two magnetic detecting elements 30 are arranged on the circumference of radius r with the angular pitch of 90 degree; however, they may be arranged with another angular pitch. Furthermore, the number of the magnetic detecting element 30 is not limited to two, but may be one or three or more.

[0036] Next, a seventh embodiment of the present invention will be explained with reference to FIG. 21. Here, portions with are substantially the same as those of the sixth embodim nt are put the same number to eliminate the explanation.

[0037] In this seventh embodiment, a rotation lever 41 for connecting to the target detection object is formed by molding the cylindrical yoke 24 and the magnet 25 by using the resin. The rotation lever 41 is rotatably supported by a rotation shaft 43 which is fixed to the connector housing 28 by being inserted and which is made of non-magnetic material. A stopper plate 44 prevent the rotation lever 41 from being removed from the rotation shaft 43. A spring washer 45 for restricting a movement of the rotation lever along a thrust direction is sandwiched between the stopper plate 44 and the rotation lever 41. The rotation lever 41 is forced to a predetermined rotational direction by a twist coil spring 46, and automatically returns to an initial position by its spring force. The other structures are substantially the same as those of the sixth embodiment.

[0038] In each embodiment in the above, the yoke and the magnet are fixed at the same side (rotor or non-rotation portion) so that the yoke and the magnet are integrally rotated or kept a non-rotational condition; however, the yoke and the magnetic detecting element may be fixed to the same side (rotor or non-rotation portion) so that the yoke and the magnetic detecting element are integrally rotated or kept a non-rotational condition. Here, an eighth embodiment in which this modification is actualized will be explained with reference to FIGS. 23 and 24. Here, portions with are substantially the same as those of the sixth embodiment (FIG. 17) are put the same number to eliminate the explanation.

[0039] In the eighth embodiment, the cylindrical yoke 24 is fixed to inside of the connector housing 28 by insert-forming or the like. the cylindrical yoke 24 is concentrically arranged with the rotation shaft 22. An arm 51 made of non-magnetic material is fixed to the tip portion of the rotation shaft 22. The magnet 25 is fixed to a side surface of a tip portion of the arm 51 by using adhesive or the like. The magnet 25 is confronted to an inner surface of the cylindrical yoke 24 with a small gap interposed therebetween. The magnet 25 is magnetized toward a radial direction of the cylindrical yoke 24, such that an S-pole is positioned toward a center portion P of the cylindrical yoke 24 and an N-pole is contacted with the inner surface of the cylindrical yoke 24. An N-pole magnetized surface of the magnet 25 is formed in a circular arc shape so as to reduce gap (magnetic resistance) between the N-pole magnetized surface of the magnet 25 and the cylindrical yoke 24. Here, positions of the S-pole and the N-pole of the magnet 25 may be exchanged with respect to FIG. 23. Here, the magnetic detecting element 30 fixed inside of the connector housing 28 is arranged in magnetic field generated between the magnet 25 and the cylindrical yoke 24, and is apart from the center portion P of the cylindrical yoke 24 by a predetermined distance r.

[0040] When the yoke 24 is the cylindrical shape like the eighth embodiment, there is no affection to distribution of the magnetic field in the yoke 24, independent of whether the yoke 24 rotates or not. Therefore, when the magnetic resistance between the magnet 25 and the cylindrical yoke 24 is reduced by arranging the magnet 25 near the inner surface of the cylindrical yoke 24, it can form a magnetic field having almost the same distribution as that of the case where the magnet 25 is fixed to the cylindrical yoke 24. Thus, the direction of the magnetic field with respect to the magnetic detecting element 30 changes in proportion to the angular position. As a result, the angular position can be detected based on the output from the magnetic detecting element 30, and the same result as in the first embodiment can be obtained.

[0041] Here, in the eighth embodiment, the shape of the yoke is not limited to the cylindrical shape. For example, the shape of the yoke may be one part of a cylinder. In short, any shape may be acceptable as long as the direction of the magnetic field is changed in proportion to the angular position within the detectable angle range. Furthermore, the yoke and the magnetic detecting element may be fixed to the rotor and the magnet may be fixed to a non-rotation portion such as the housing.

[0042] Next, a ninth embodiment of the present invention will be explained with reference to FIGS. 25 to 31. In the ninth embodiment, as shown in FIGS. 25 and 26, a cylindrical yoke 53 to which a magnet 52 is fixed is concentrically fixed to a rotor (not-shown) that is connected to the target detection object. Incidentally, two magnetic detecting elements 54 and 55 each of which is fixed to a non-rotation portion (not-shown) of a housing or the like are arranged on the circumference of radius r whose center is a rotation axis P of the cylindrical yoke with the angular pitch of 90 degree, and are arranged in magnetic field generated between the magnet 52 and the cylindrical yoke 53. Thus, each of two magnetic detecting elements 54 and 55 is arranged so that a range of angular position in which the output change characteristic becomes linear (linear region) is different from each other.

[0043] It assumes that an angular position when one magnetic detecting element 54 positions on a center line XXVI-XXVI, as shown in FIG. 25, is 0 degree, and that a counterclockwise direction is a positive direction of the angular position. In this case, as shown in FIG. 28, outputs of the one magnetic detecting element 54 shows a minimum at -90 d gree, and shows a maximum at 0 degree and at +90 d gr e. On the contrary, outputs of another magnetic detecting element 55 shows a minimum at 0 degree, and shows a maximum at 0 degree and at +180 degree. Therefore, each of

the outputs of the two magnetic detecting elements 54 and 55 has the same waveform but whose phases are shifted by 90 degree each other. That is, the linear region A of the outputs of the one magnetic detecting element 54 and the linear region B of the outputs of another magnetic detecting element 55 are shifted by 90 degree in phase.

[0044] As shown in FIG. 27, the outputs of the two magnetic detecting elements 54 and 55 are respectively amplified by amplifiers 56 and 57 (see FIG. 29). Amplification factors (gains) of the amplifiers 56 and 57 are set to be equal. Each amount of offsets a and b is respectively added to the output of each amplifier 56 and 57 (amplified output of each magnetic detecting element 54 and 55) by an offset circuit 56 and 57, so that the output is offset to a positive voltage side (FIG 30). One of outputs from the offset circuits 58 and 59 (offset outputs from the magnetic detecting element) is selected by an output selector 60 (output selecting means), and is outputted as a final sensor output (FIG. 31). Each of the amount of offsets a and b from each offset circuit 58 and 59 is determined so that the offset outputs from the magnetic detecting elements 54 and 55 is continued on a straight line, when the offset outputs of the magnetic detecting elements 54 and 55 are selected by the output selector 60. An output switching point is a center portion (+45 degree) of the linear regions A and B of the two magnetic detecting elements 54 and 55. Therefore, the offset outputs from the one magnetic detecting element 54 is selected when the angular position is 45 degree or less; whereas the offset outputs from another magnetic detecting element 55 is selected when the angular position is 45 degree or more.

[0045] Incidentally, the offset outputs of the magnetic detecting elements 54 and 55 are changed in accordance with the angular position. Therefore, as described in the ninth embodiment, when the detectable angle range becomes broader, the offset outputs of a particular one magnetic detecting element becomes the same at different two angular position. Therefore, when only offset outputs of the particular one magnetic detecting element are used, the switching point of the offset outputs of the magnetic detecting elements 54 and 55 may be falsely judged.

[0046] Therefore, according to the ninth embodiment, the output selector 60 switches the offset outputs of the magnetic detecting elements 54 and 55, by judging the switching point of the offset outputs of the magnetic detecting elements 54 and 55. Here, the output selector 60 performs the judgment by adding up the offset outputs of the magnetic detecting elements 54 and 55, and comparing a sum of the offset outputs with a reference value S3. In this case, the reference value S3 for output switching is set to the maximum value of the offset outputs of the magnetic detecting element 55. Therefore, when the sum of the offset outputs is the reference value S3 or less, the output selector 60 selects the offset outputs from the one magnetic detecting elements 54; whereas when the sum of the offset outputs is the more than reference value S3, the output selector 60 selects the offset outputs from another magnetic detecting elements 55. Here, the reference value S3 is not limited. For example, the sensor outputs at the output switching point (+45 degree) is investigated, and the reference value S3 may be determined to a twice value of the investigated value. The amplification, the offset, and the conversion of the output from the magnetic detecting elements 54 and 55 may be actualized by using hardware or by software using a microcomputer.

[0047] When one of the outputs, which are on the linear regions A and B of the two magnetic detecting elements 54 and 55 each of which is arranged at different position, are switched, the range of the angular position (detectable angular range) in which the output change characteristic of the angular position detecting apparatus becomes linear (detectable angle range) can be dramatically expanded.

[0048] Here, when three or more magnetic detecting elements are arranged at different positions, and when one of outputs on the liner region is selected, the detectable angle range can be further expanded.

[0049] Incidentally, according to the angular position apparatus using the magnetic detecting element, detection accuracy is best at a point where the output of the magnetic detecting element becomes zero. This is because the point where the output of the magnetic detecting element becomes zero is the center of the linear region of the outputs, and th refore the linearity becomes the best. Furthermore, when the output of the magnetic detection is zero, influence to th magnetic detecting element due to a thermal characteristic becomes small. Conventionally, an output error due to a thermal characteristic of the magnetic detecting element is compensated by using a thermal compensation element. However, it is quite difficult to completely eliminate the output error due to the thermal characteristic to zero, because of a variation of the magnetic detecting element or a variation of the thermal compensation element. Therefore, the detection accuracy becomes the best in the whole detectable angle range at the point where the output of the magnetic detecting element becomes zero.

[0050] In view of the above characteristic, according to a tenth embodiment shown in FIGS. 32 to 36, the magnet 52 and the magnetic detecting element 54 are arranged so that the output of the magnetic detecting element 54 becomes zero at a particular angular position (accuracy required point) at which the detection accuracy is extremely required. Furthermore, in order to accord the output of the angular position detecting apparatus (hereinafter, called "sensor") with a required output change characteristic, the output of the magnetic detecting element 54 is amplified in the amplifier 61 (see FIG. 35), outputs of the amplifier 61 is offset by the offset circuit 62 (FIG. 36), and outputs of the offset circuit 62 is outputted as a sensor output. The amplifier circuit 61 and the offset circuit 62 correspond to output adjusting means. Other structures are the same as those of the ninth embodiment.

[0051] In this case, the amplification factor of th amplifier 61 is determined by the following equations.

$$\text{AMPLIFICATION FACTOR} = [S(\theta max)-S(\theta min)]/[V(\theta max)-V(\theta min)]$$

[0052] Here, $S(\theta)$ is a required output of the sensor when the angular position is θ; $V(\theta)$ is an output of the magnetic detecting element 54 when the angular position is θ; $S(\theta max)$ is a maximum detected angular position; and $S(\theta min)$ is a minimum detected angular position.

[0053] Therefore, as shown in FIG. 35, an inclination of the change characteristic of the output of the amplifier 61 (amplified output of the magnetic detecting element 54) becomes the same as an inclination of the required output change characteristic of the sensor.

[0054] Furthermore, an amount of offset c of the offset circuit 62 is a difference between the required output of the sensor and the amplified output of the magnetic detecting element 54. The offset circuit 62 matches the amount of offset c to the amplified output of the amplifier to the final sensor output by adding the amount of offset c to the amplified output of the magnetic detecting element 54 to offset it to the positive voltage side. As a result, a final output change characteristic of the sensor can be modified to meet a specification of an external control circuit to be connected to the sensor without changing the specification of the external control circuit.

[0055] The structure described in the tenth embodiment can be applied to other kinds of angular position detecting apparatus for several kinds of rotor, such as a throttle openings degree detecting apparatus that detects a throttle opening degree (an angular position of the throttle valve). A detectable range of the throttle openings degree detecting apparatus is approximately 100 degree, from a fully closed to a fully opened. Furthermore, the throttle opening degree during an idle driving is set to around 5 degree which is a fully closed position, and detection accuracy is extremely required around this throttle opening degree during the idle driving. Therefore, when the structure in the tenth embodiment is applied to the throttle opening degree detecting apparatus, the magnet 52 and the magnetic detecting element 54 are arranged so that the outputs of the magnetic detecting element 54 becomes zero at around the throttle opening degree during the idle driving. As a result, the influence to the thermal characteristic of the magnetic detecting element 54 can be reduced to the minimum at around the throttle opening degree during the idle driving in which the detection accuracy is severely required. Hence, the detection accuracy of the angular position can be improved.

[0056] Here, in the example shown in FIG. 34, the accuracy required point is set to around 5 degree. However, the accuracy required point can be voluntary determined within an available range. In each case, since the accuracy required point is always a zero-output point, a position of the available range is relatively shifted.

[0057] Furthermore, in each embodiment, a magnetic shield (shelter) member may be provided to cover the opening of the yoke so as to eliminate an influence due to an external magnetic field to the magnetic detecting element. Here, when the magnetic shield member is arranged too close to the yoke, a magnetic circuit is formed between the magnetic shield member and the yoke, and therefore the distribution of the magnetic field inside the yoke is changed. Therefore, it is preferable to set a gap between the magnetic shield member and the yoke so that no magnetic circuit is formed.

[0058] The present invention is not limited to the throttle opening degree detecting apparatus, but is applicable to several kinds of angular position detecting apparatus.

[0059] An angular position detecting apparatus using a magnetic detecting element, which can voluntary widely set an output change characteristic of the magnetic detecting element with respect to angular positions. An angular position detecting apparatus includes a cylindrical yoke (11), and a magnet (12) fixed to a predetermined position in the cylindrical yoke. A magnetic detecting element (13), which is fixed to a rotor, is provided in a magnetic field generated between the magnet and the cylindrical yoke, so that a position of the magnetic detecting element is shifted from a rotation axis P of the rotor by a predetermined distance r. A ferromagnetic thin film magnetic resistance element applies a magnetic field which has intensity so that outputs from the elements are saturated. As a result, the magnetic detecting element generates outputs depending only on a magnetic flux detection angle θs independent of an influence of changes of magnetic field intensity due to temperature changes. In this case, when at least one of a rotation radius r of the magnetic detecting element and a radius R of the cylindrical yoke is voluntary determined, an output change characteristic of the magnetic detecting element can be voluntary set.

Claims

1. An angular position detecting apparatus comprising:

   a non-rotation portion (21);
   a rotor (22) rotatably supported by the non-rotation portion for being rotated in response to a rotation of a target detection object;
   a magnet (12,25) magnetized in one direction, and provided at one member of set consisting of the non-rotation portion and the rotor;
   a yoke (11,24) provided at a same member of the set consisting of the non-rotation portion and the rotor, as

the magnet, the yoke for generating magnetic field between the yoke and the magnet; and
a magnetic detecting element (13,30,54,55) provided in the magnetic field and provided at a different member of the set consisting of the non-rotation portion and the rotor, the magnetic detecting element offset from a rotation axis of the rotor, and the magnetic detecting element for outputting an output signal in response to the rotation of the rotor.

2. An angular position detecting apparatus comprising:

a non-rotation portion (21);
a rotor (22) rotatably supported by the non-rotation portion for being rotated in response to a rotation of a target detection object;
a magnet (12,25) magnetized in one direction, and provided at one member of set consisting of the non-rotation portion and the rotor;
a yoke (11,24) provided at a different member of the set consisting of the non-rotation portion and the rotor, the yoke for generating magnetic field between the yoke and the magnet; and
a magnetic detecting element (13,30,54,55) provided in the magnetic field and provided at a same member of the set consisting of the non-rotation portion and the rotor, as the yoke, the magnetic detecting element offset from a rotation axis of the rotor, and the magnetic detecting element for outputting an output signal in response to the rotation of the rotor.

3. An angular position detecting apparatus according to claim 1 or 2, wherein:

the yoke (11,24) has a shape one of a cylinder, an ellipse, a part of a cylinder, and a part of an ellipse; and
the magnet (12, 25) is arranged so that one pole thereof is positioned toward the rotation axis of the yoke.

4. An angular position detecting apparatus according to any one of claims 1 - 3, wherein the magnet (12, 25) is arranged so that another pole thereof contacts with the yoke (11,24).

5. An angular position detecting apparatus according to any one of claims 1 - 4, wherein an amount of offset of the magnetic detecting element (13,30,54,55) from the rotation axis of the rotor is determined so that an angle θs of magnetic flux to be detected by the magnetic detecting element is smaller than an angular position θm of the rotor.

6. An angular position detecting apparatus according to any one of claims 1 - 5, wherein a radius of curvature of the yoke (11,24) is determined so that an angle θs of magnetic flux to be detected by the magnetic detecting element (13,30,54,55) is smaller than an angular position θm of the rotor.

7. An angular position detecting apparatus according to any one of claims 1 - 6, wherein an amount of offset of the magnetic detecting element (13,30,54,55) from the rotation axis of the rotor is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes linear.

8. An angular position detecting apparatus according to any one of claims 1 - 7, wherein a radius of curvature of the yoke (11,24) is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes linear.

9. An angular position detecting apparatus according to any one of claims 1 - 8, wherein an amount of offset of the magnetic detecting element (13,30,54,55) from the rotation axis of the rotor is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes a curve having an upper convex.

10. An angular position detecting apparatus according to any one of claims 1 - 9, wherein a radius of curvature of the yoke (11,24) is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes a curve having an upper convex.

11. An angular position detecting apparatus according to any one of claims 1 - 10, wherein an amount of offset of the magnetic detecting element (13,30,54,55) from the rotation axis of the rotor is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes a curve having a lower convex.

12. An angular position detecting apparatus according to any one of claims 1 - 11, wherein a radius of curvature of the yoke (11,24) is determined so that an output change characteristic of the magnetic detecting element with respect to an angular position θm of the rotor becomes a curve having a lower convex.

13. An angular position detecting apparatus according to any one of claims 1 - 12, wherein:

the magnet (12,25) applies magnetic field having intensity so that outputs signal of the magnetic detecting elements are saturated; and
the magnetic detecting element (13,30,54,55) is made up of a ferromagnetic thin film magnetic resistance element (13a), and outputs the output signal in response to the angle of the magnetic flux crossing the ferromagnetic thin film magnetic resistance element.

14. An angular position detecting apparatus according to any one of claims 1- 13, wherein plural magnetic detecting elements (13,30,54,55) are arranged on a common circumference whose center corresponds to the rotation axis of the rotor.

15. An angular position detecting apparatus comprising:

plural magnetic detecting elements (13,30,54,55) for outputting an output signal in response to a rotation of a target detection object, each of the magnetic detecting elements having a range of an angular position in which an output characteristic becomes linear, the range being different from each other with respect to every magnetic detecting element; and
an output selector (60) for selectively outputting outputs of a particular magnetic detecting element in a linear region, depending on the angular position.

16. An angular position detecting apparatus according to claim 15, further comprising:

an output adjustor (61,62) for adjusting at least one of an amount of offset and an amplification factor regarding the outputs of the magnetic detecting elements (13,30,54,55), so that the outputs of the magnetic detecting elements are connected as a straight line.

17. An angular position detecting apparatus according to claim 15 or 16, wherein:

the output selector (60) adds up the outputs of the magnetic detecting elements (13,30,54,55), and determines an output switching point at which the outputs of the magnetic detecting elements are switched based on a sum of the outputs of the magnetic detecting elements.

18. An angular position detecting apparatus according to any one of claims 15 - 17, further comprising:

a non-rotation portion (21);
a rotor (22) rotatably supported by the non-rotation portion for being rotated in response to a rotation of the target detection object;
a magnet (12,25) magnetized in one direction, and provided at one member of set consisting of the non-rotation portion and the rotor; and
a yoke (11,24) for generating magnetic field between the yoke and the magnet,
wherein the magnetic detecting element (13,30,54,55) are provided in the magnetic field and provided at a different member of the set consisting of the non-rotation portion and the rotor, the magnetic detecting elements offset from a rotation axis of the rotor, and the magnetic detecting element for outputting an output signal in response to the rotation of the rotor.

19. An angular position detecting apparatus comprising:

a magnetic detecting element (13,30,54,55) for outputting an output signal in response to a rotation of one of a magnet (12,25) and the magnetic detecting element as a result of rotation of a target detection object,
wherein the magnet and the magnetic detecting element are arranged so that outputs of the magnetic detecting element becomes substantially zero at around a particular angular position at which detection accuracy is extremely required.

20. An angular position detecting apparatus according to claim 19, further comprising:

an output adjustor (61,62) for amplifying the outputs of the magnetic detecting elements (13,30,54,55), for offsetting the amplified outputs, so that an output change characteristic of the angular position detecting apparatus accords with a required output change characteristic.

21. An angular position detecting apparatus according to claim 19 or 20, further comprising:

a non-rotation portion (21);
a rotor (22) rotatably supported by the non-rotation portion for being rotated in response to a rotation of the target detection object;
a magnet (12,25) magnetized in one direction, and provided at one member of set consisting of the non-rotation portion and the rotor; and
a yoke (11,24) for generating magnetic field between the yoke and the magnet,
wherein the magnetic detecting element (13,30,54,55) is provided in the magnetic field and provided at a different member of the set consisting of the non-rotation portion and the rotor, the magnetic detecting element offset from a rotation axis of the rotor, and the magnetic detecting element for outputting an output signal in response to the rotation of the rotor.

22. An angular position detecting apparatus according to any one of claims 1 - 21, wherein the target detection object is a throttle valve, and a throttle valve opening degree is detected based on the outputs of the magnetic detecting element (13,30,54,55).

FIG. 1

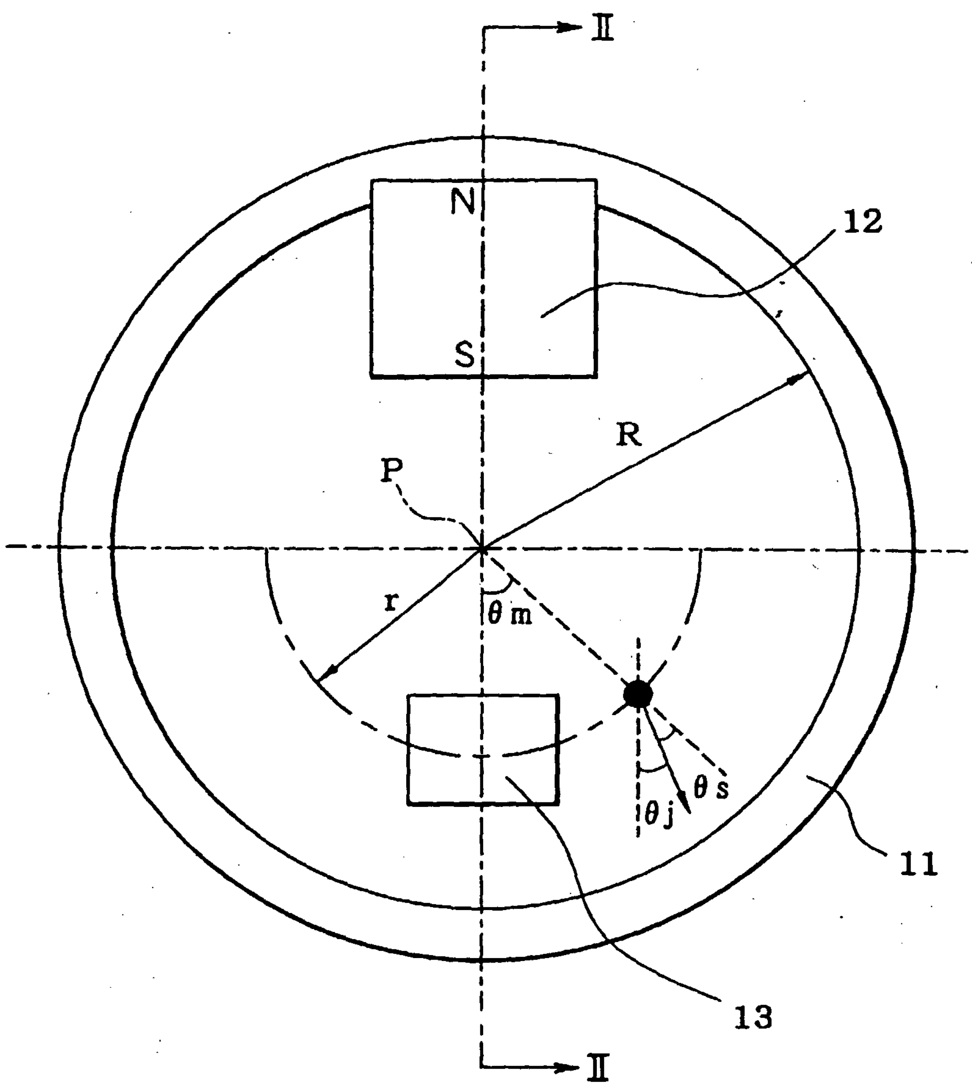


FIG. 2

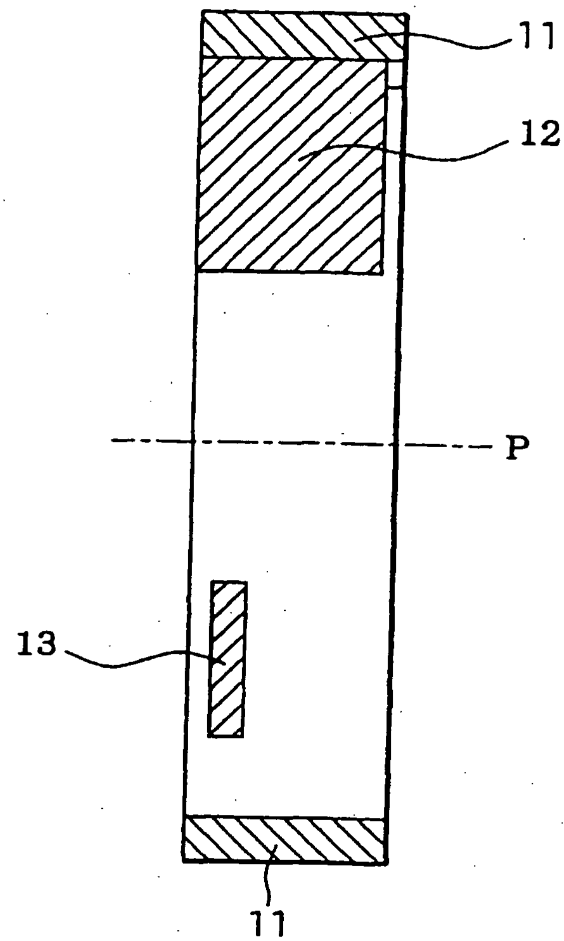


FIG. 3

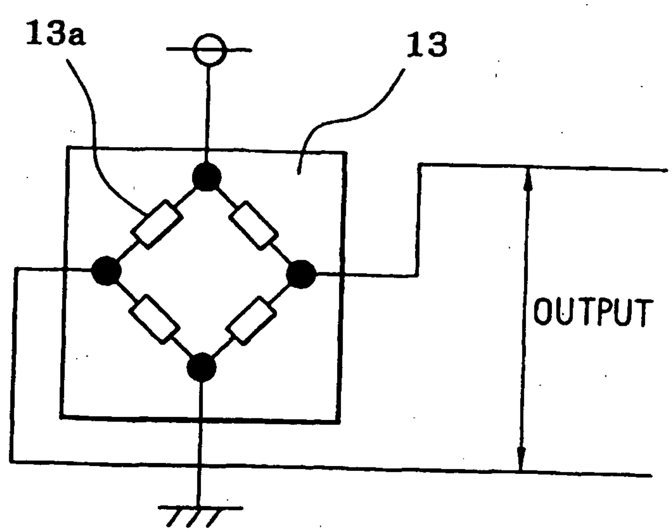


FIG. 4

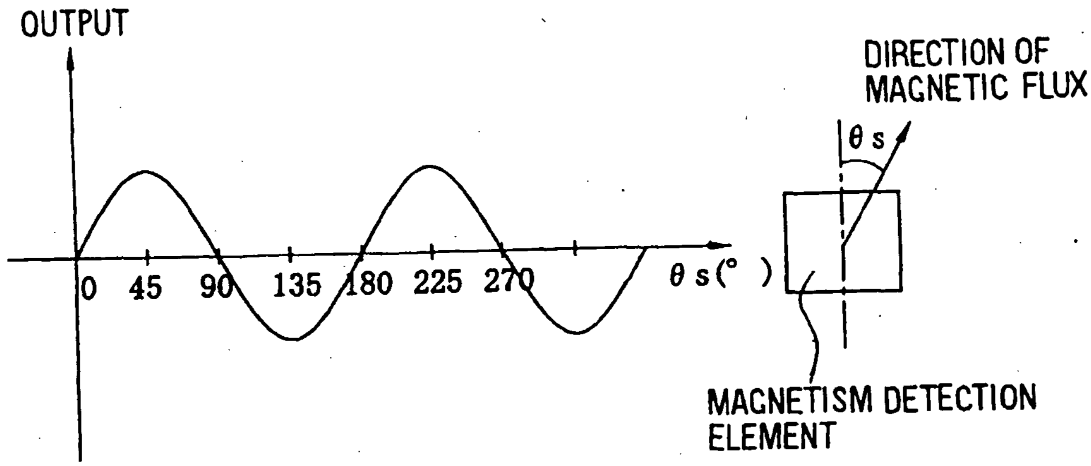

OUTPUT
0
45
90
135
180
225
270
θ s(°)
DIRECTION OF
MAGNETIC FLUX
θ s
MAGNETISM DETECTION
ELEMENT

FIG. 5

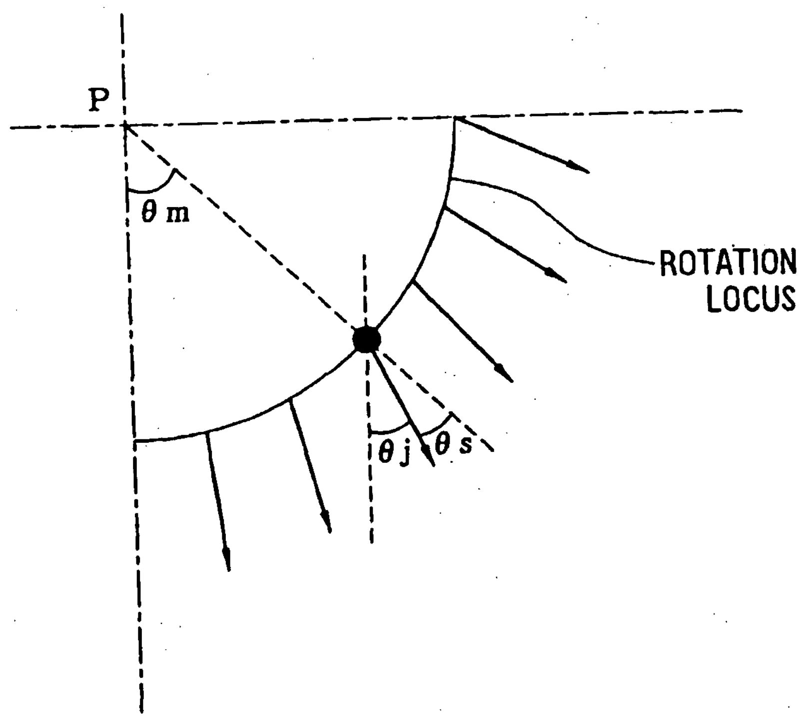

P
θ m
ROTATION
LOCUS
θ j
θ s

FIG. 6

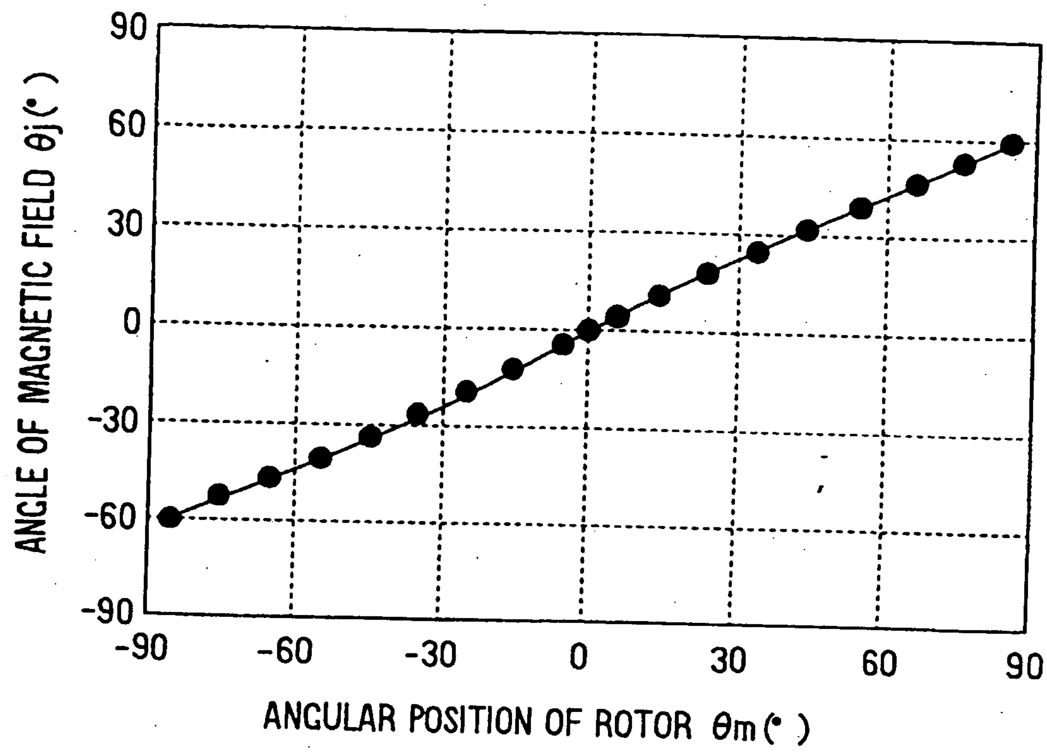

ANGLE OF MAGNETIC FIELD θj(°)
90
60
30
0
-30
-60
-90
-90
-60
-30
0
30
60
90
ANGULAR POSITION OF ROTOR θm(°)

FIG. 7

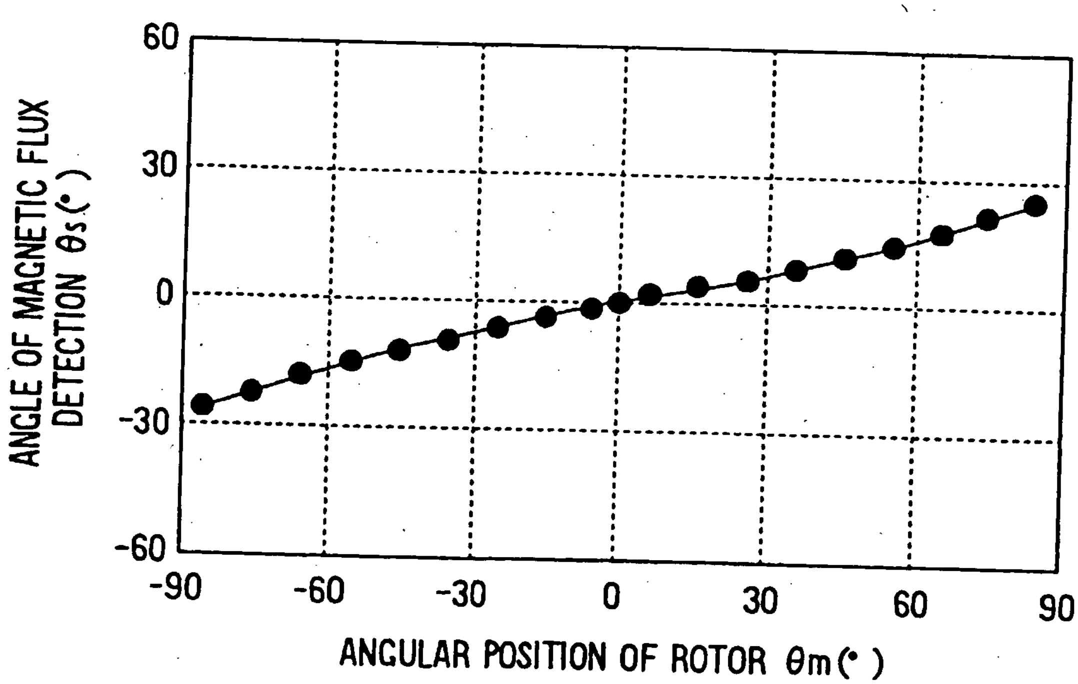

ANGLE OF MAGNETIC FLUX DETECTION θs(°)
60
30
0
-30
-60
-90
-60
-30
0
30
60
90
ANGULAR POSITION OF ROTOR θm(°)

FIG. 8A PRIOR ART

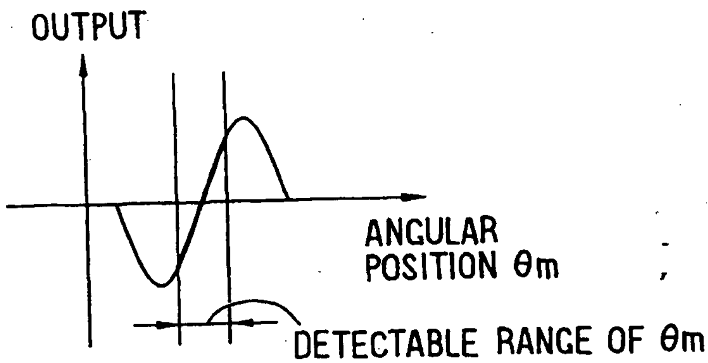


FIG. 8B

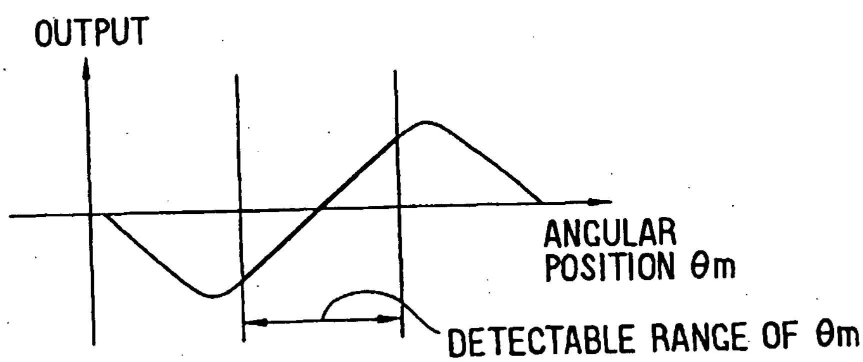


FIG. 9

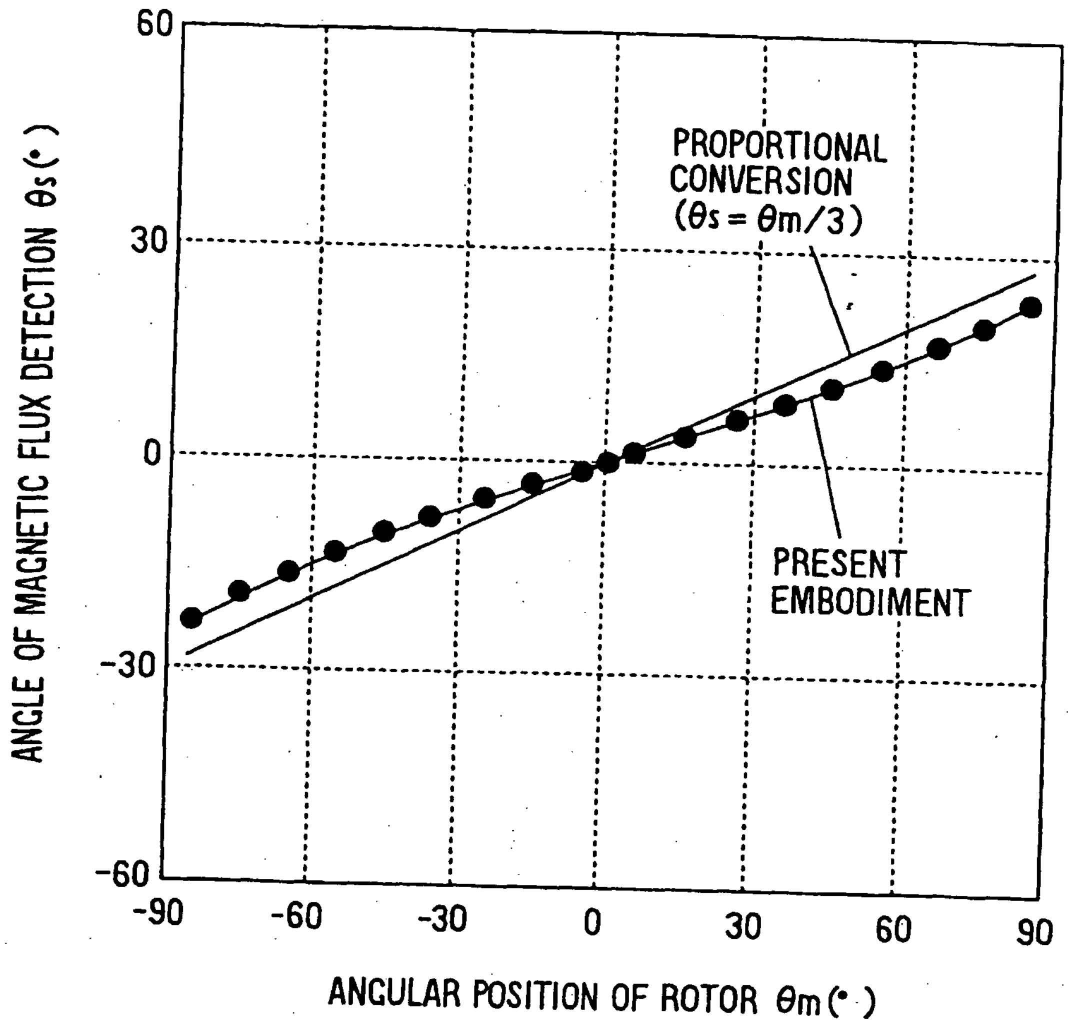

60
30
0
-30
-60
-90
-60
-30
0
30
60
90
ANGLE OF MAGNETIC FLUX DETECTION θs(°)
ANGULAR POSITION OF ROTOR θm(°)
PROPORTIONAL CONVERSION (θs = θm/3)
PRESENT EMBODIMENT

FIG. 10

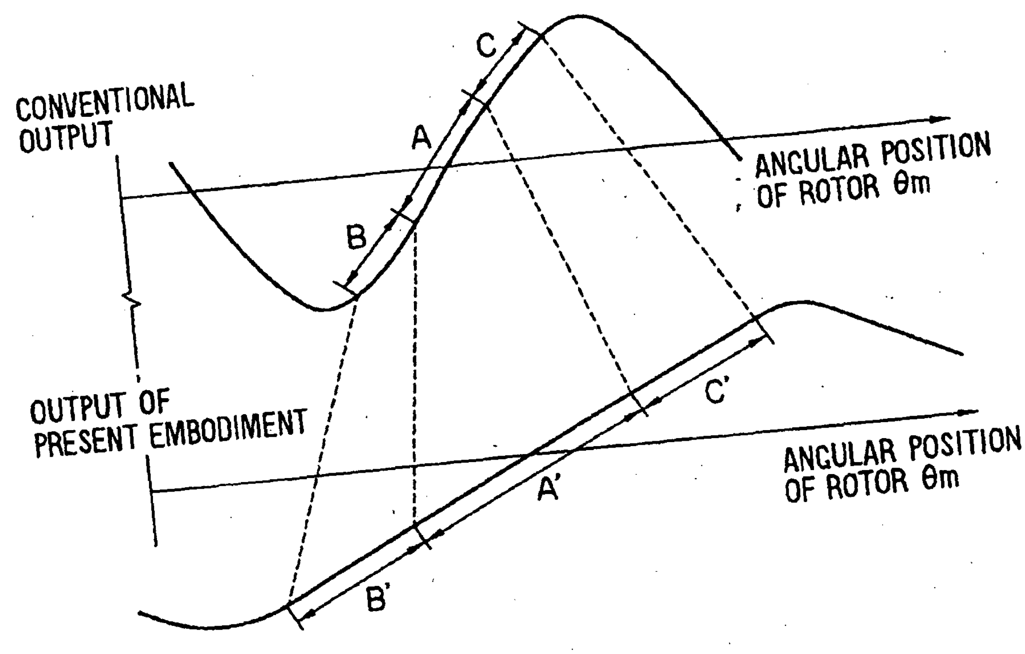
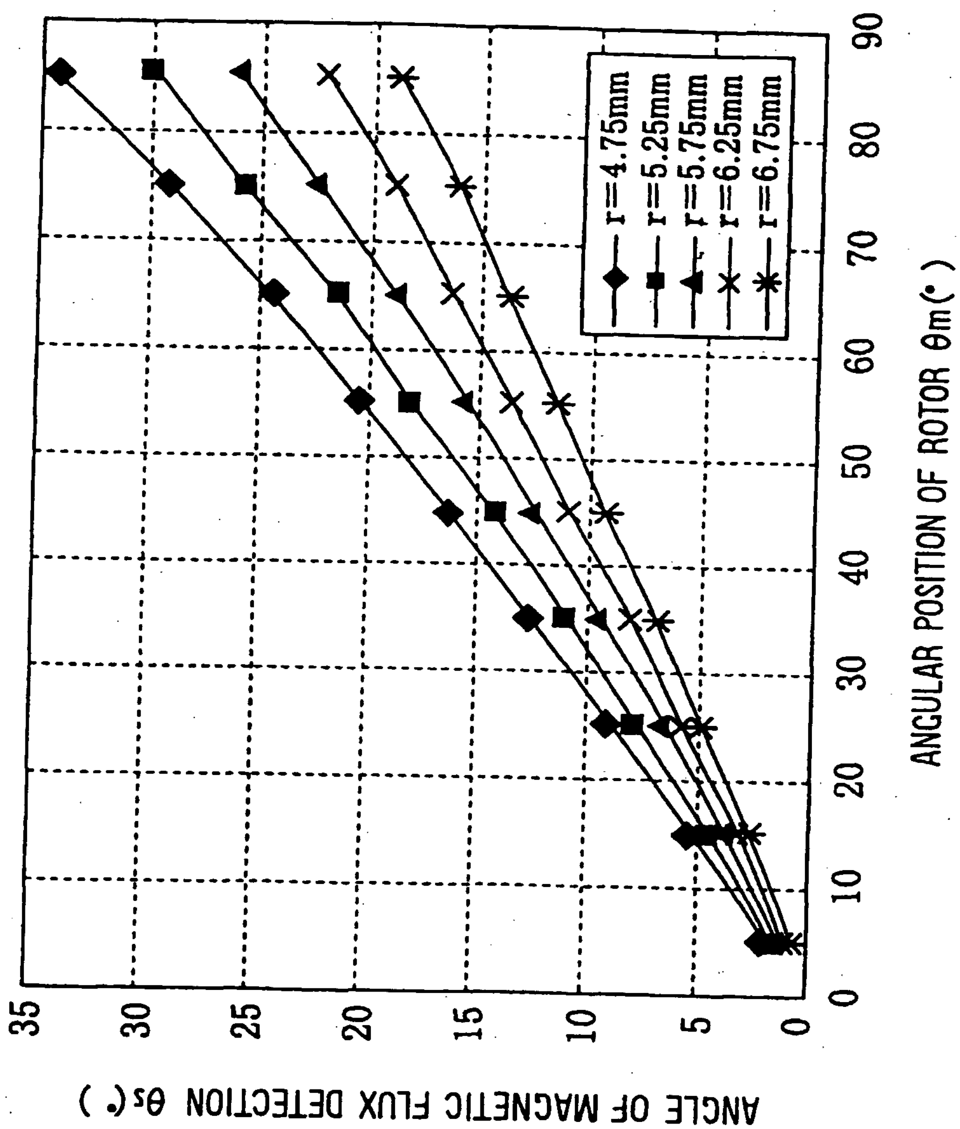
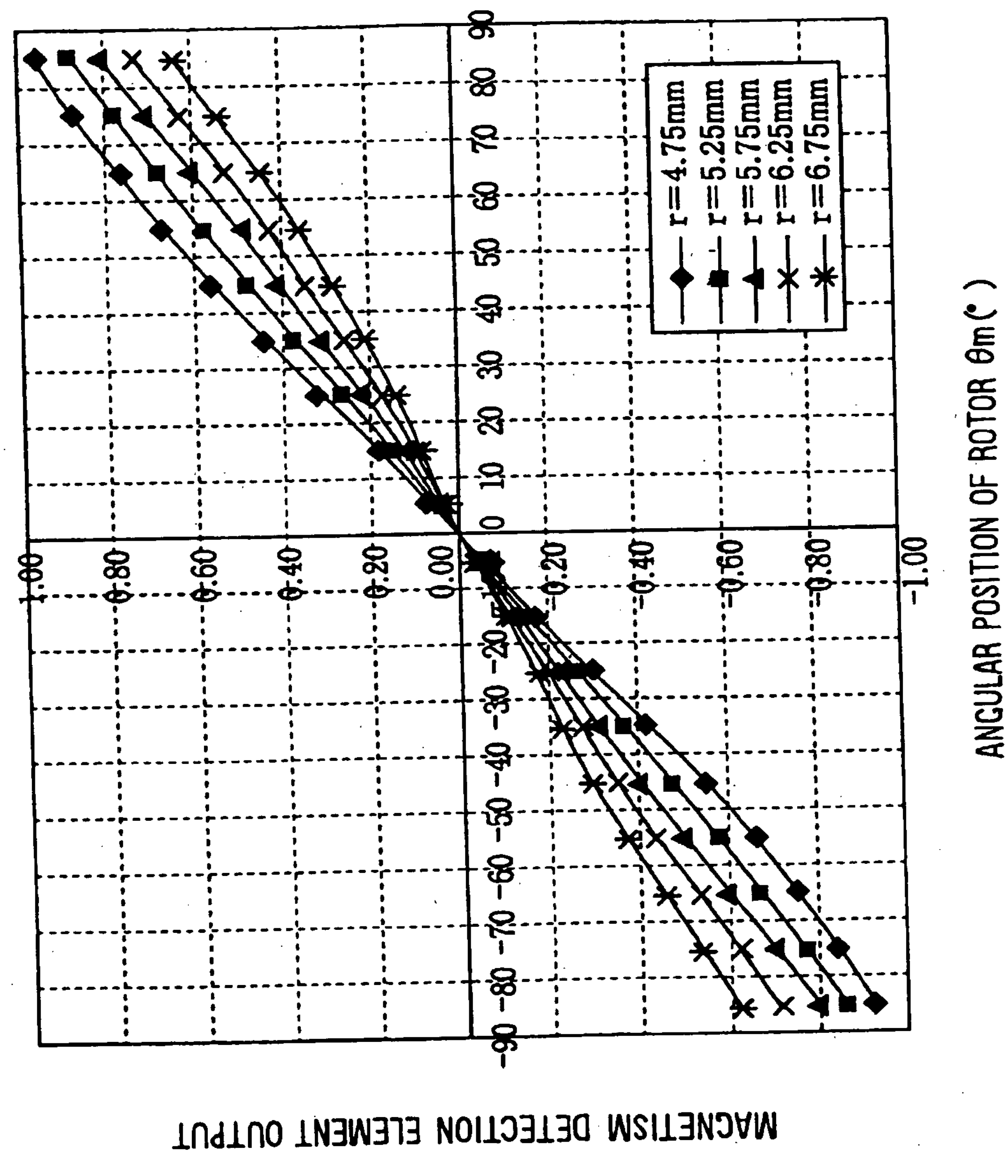

CONVENTIONAL OUTPUT
C
A
B
ANGULAR POSITION OF ROTOR θm
OUTPUT OF PRESENT EMBODIMENT
C'
A'
B'
ANGULAR POSITION OF ROTOR θm

FIG. 11



r=4.75mm
r=5.25mm
r=5.75mm
r=6.25mm
r=6.75mm
ANGULAR POSITION OF ROTOR θm(°)
ANGLE OF MAGNETIC FLUX DETECTION θs(°)
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35

FIG. 12



r=4.75mm
r=5.25mm
r=5.75mm
r=6.25mm
r=6.75mm
ANGULAR POSITION OF ROTOR θm(°)
MAGNETISM DETECTION ELEMENT OUTPUT

FIG. 13A

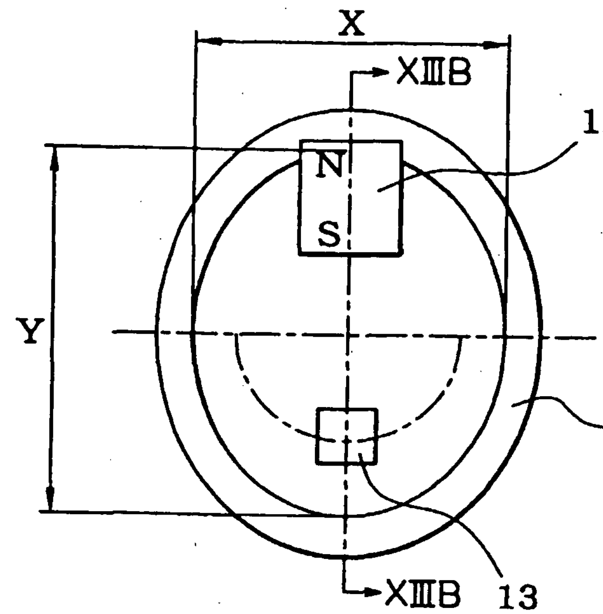


FIG. 13B

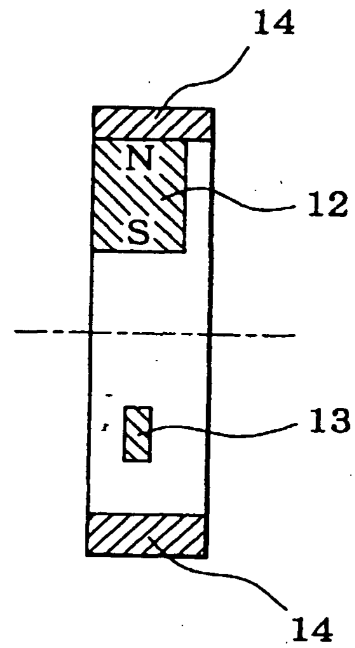


FIG. 14A

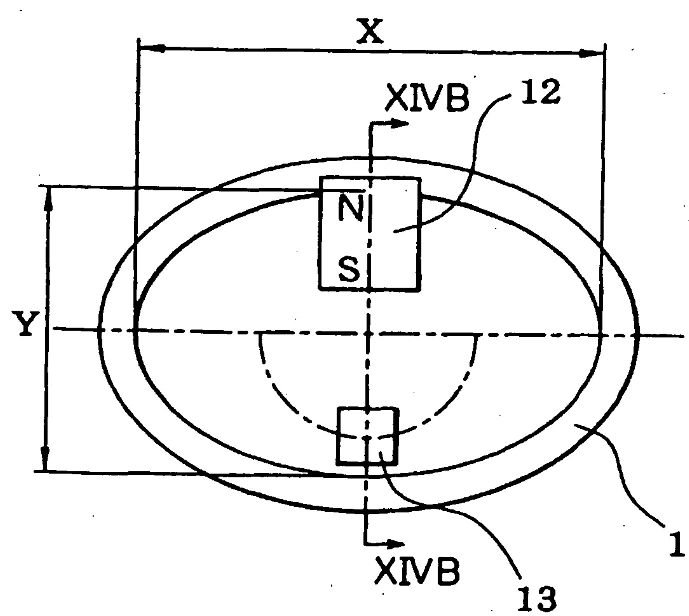


FIG. 14B

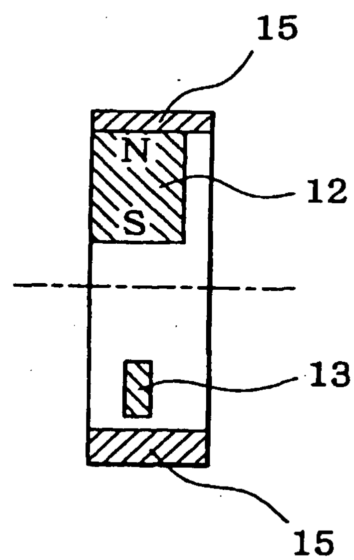


FIG. 15A

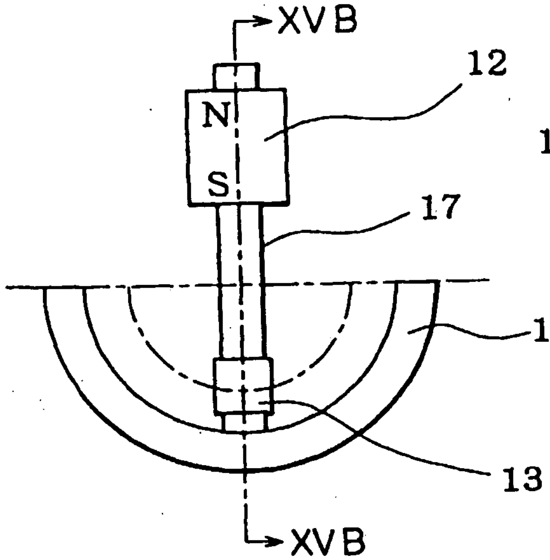


FIG. 15B

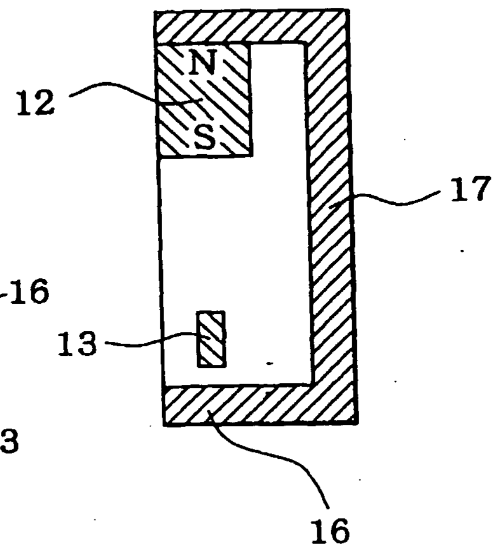


FIG. 16

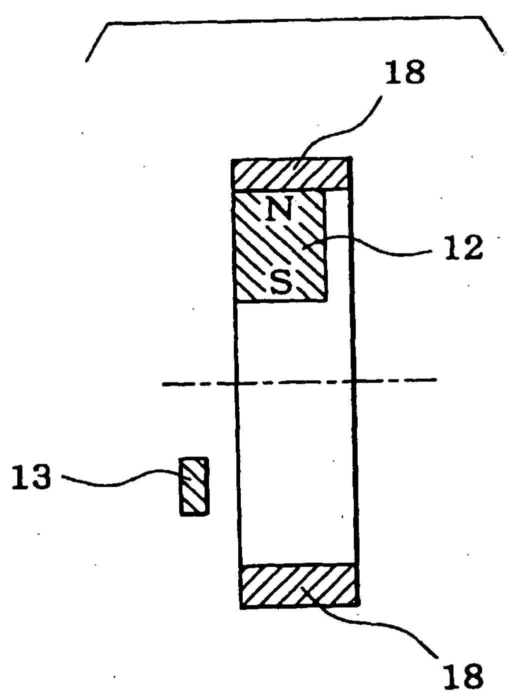


FIG. 17

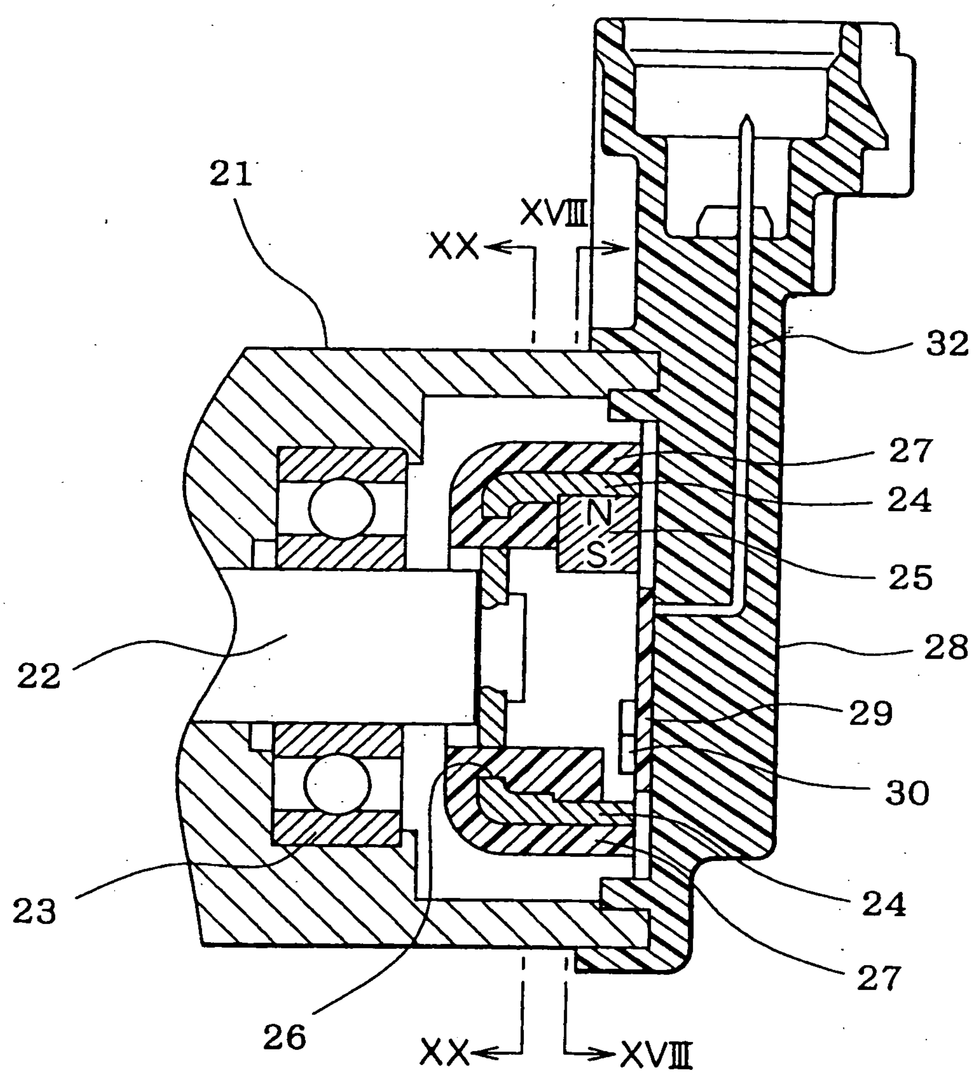


FIG. 18

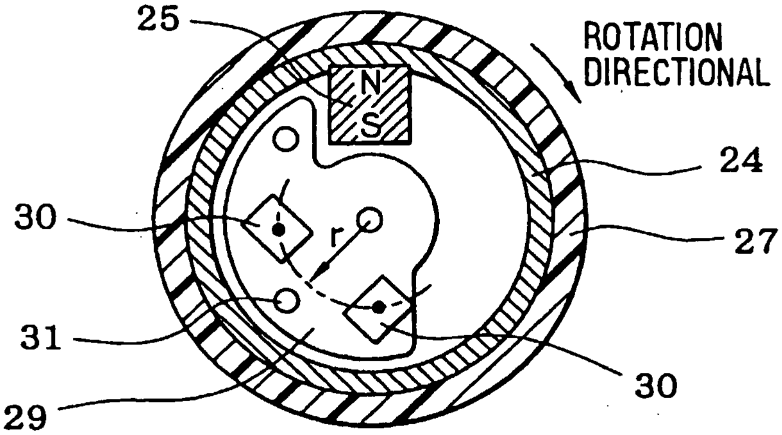


FIG. 19

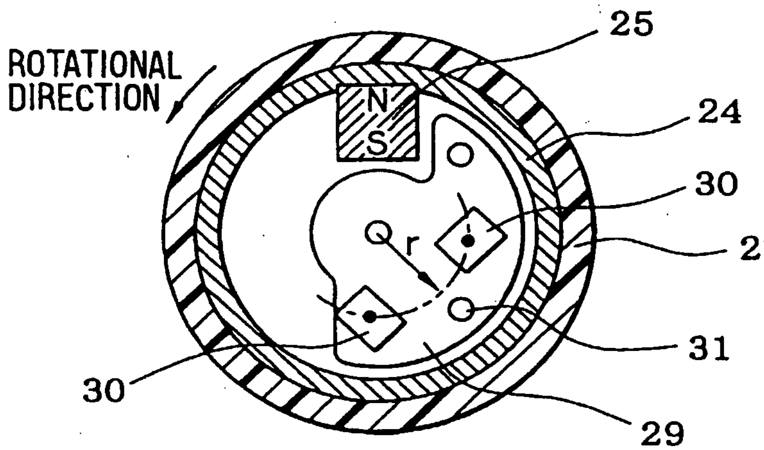


FIG. 20

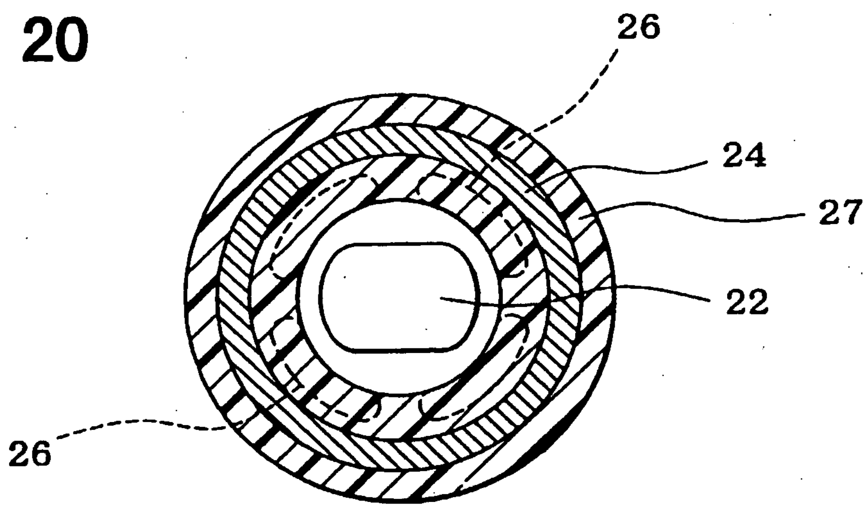


FIG. 21

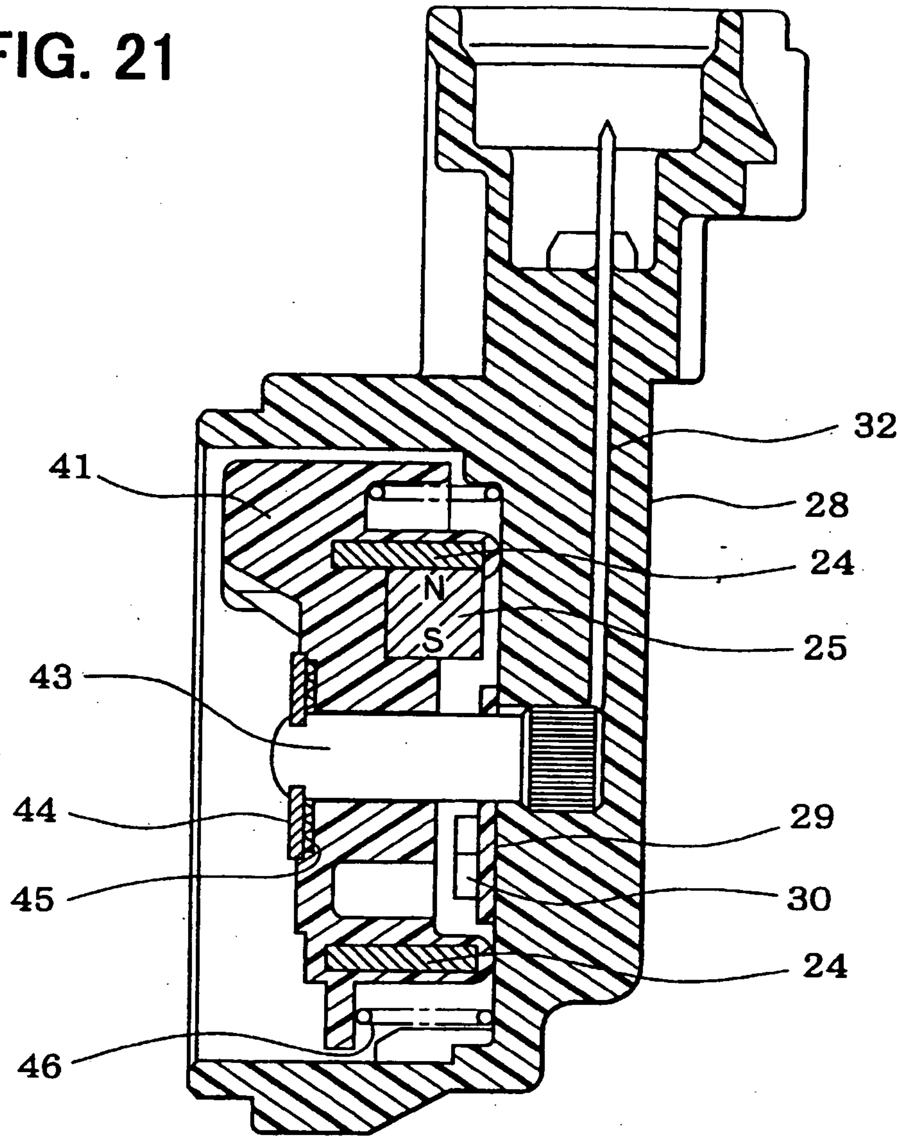


FIG. 22

PRIOR ART

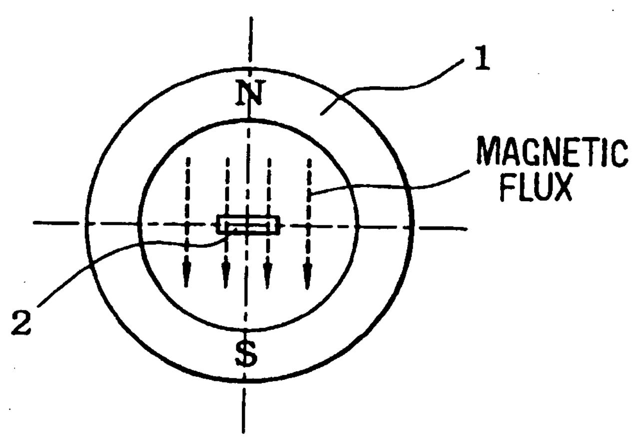


FIG. 23

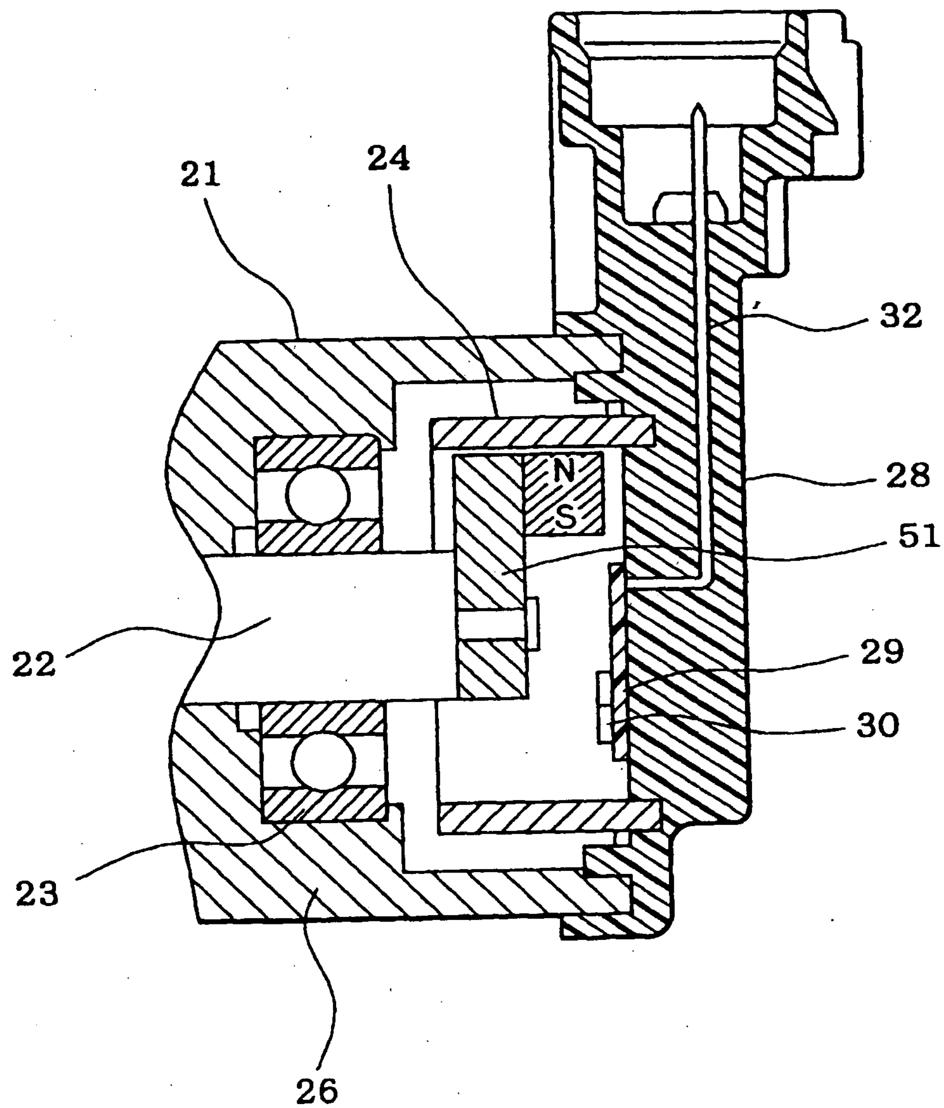


FIG. 24

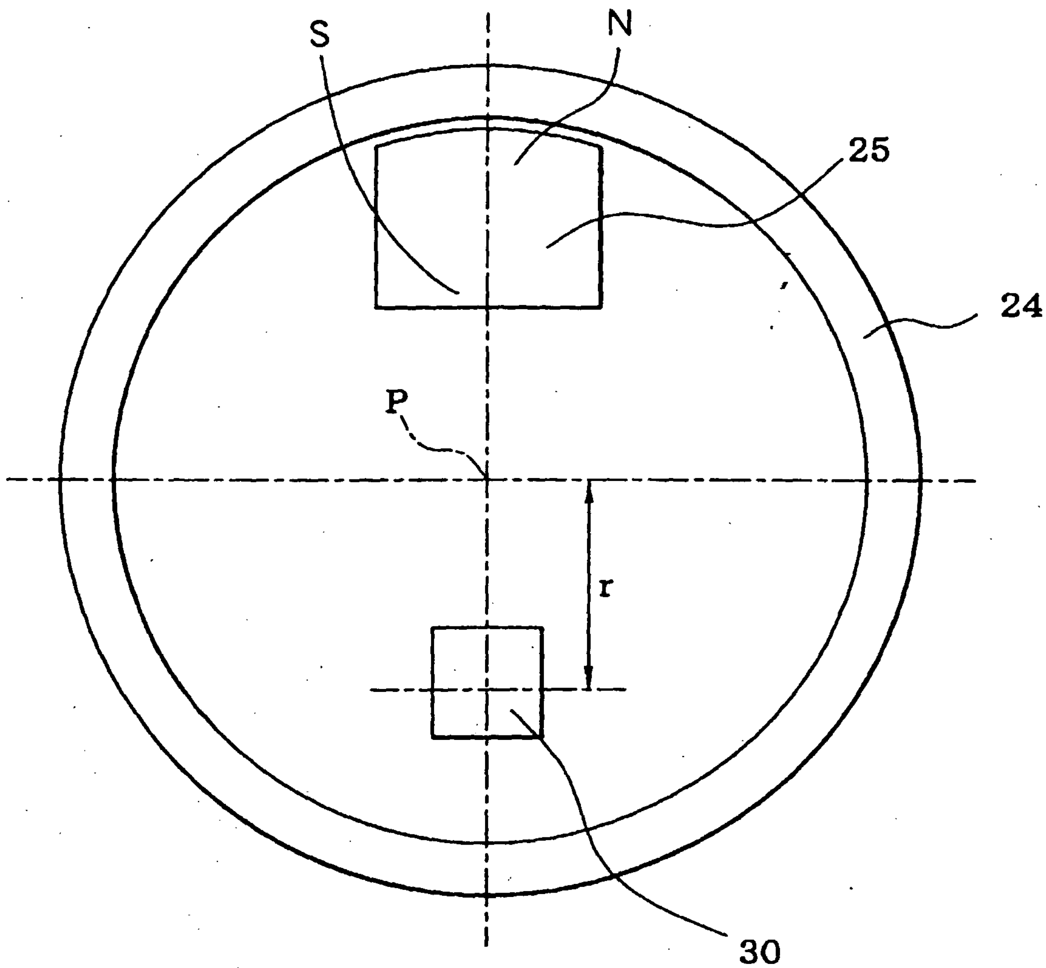


FIG. 25

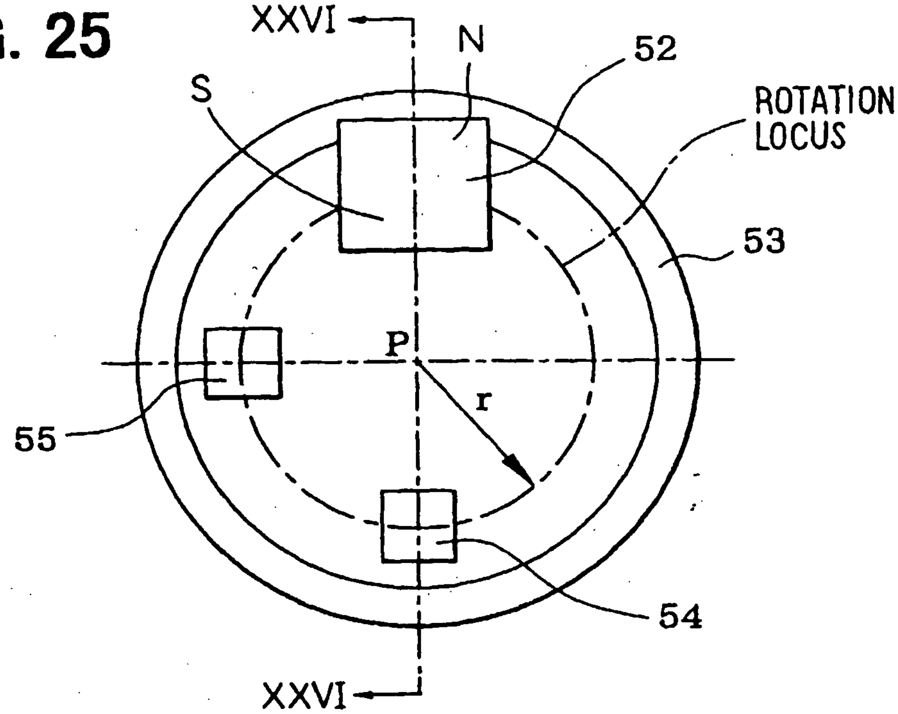


FIG. 26

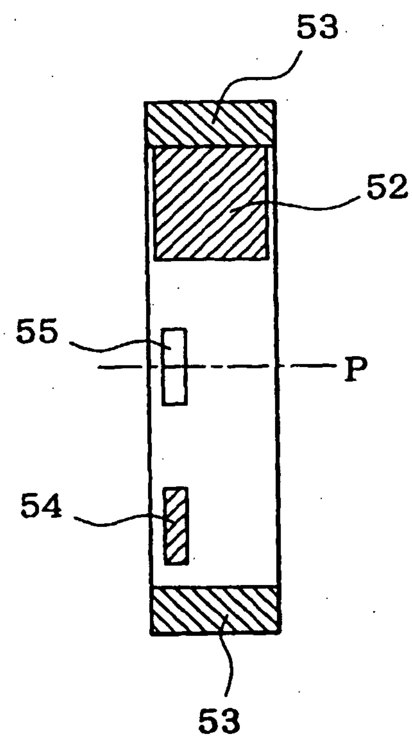


FIG. 27

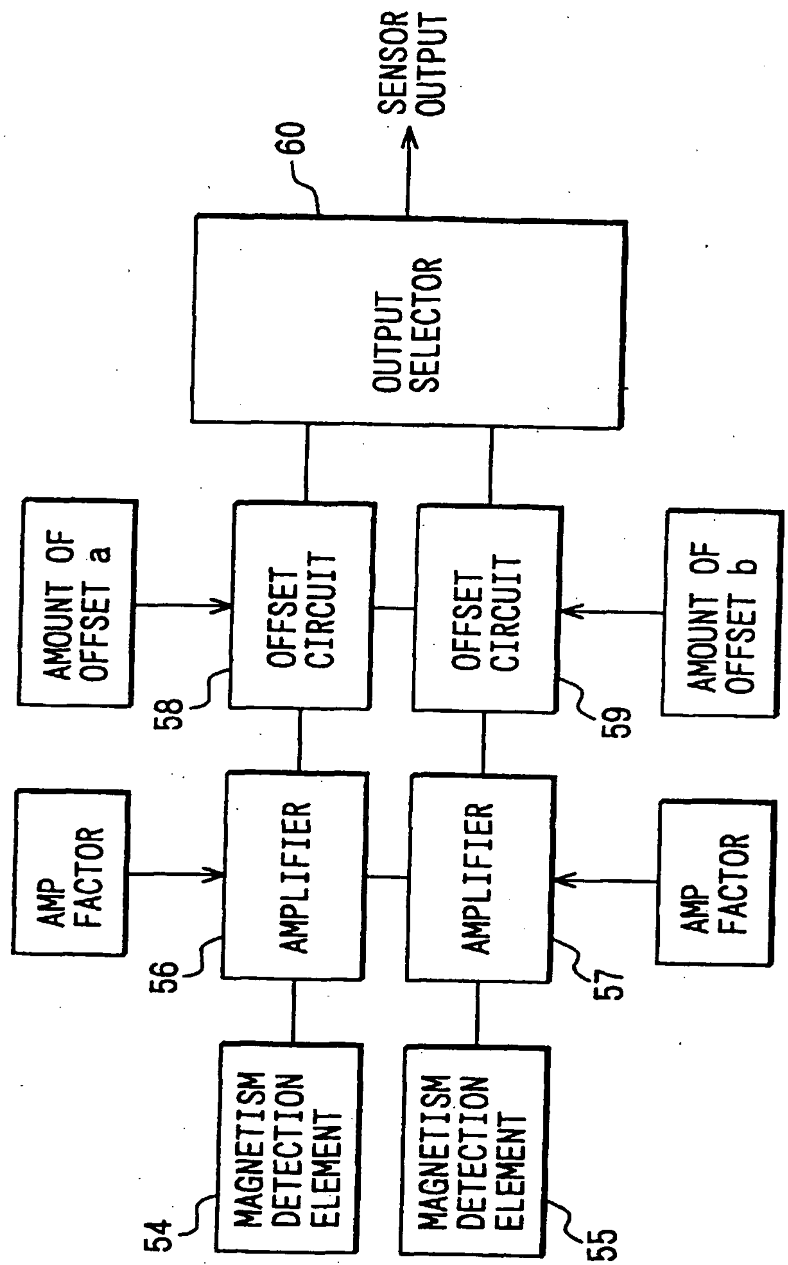

SENSOR OUTPUT
60
OUTPUT SELECTOR
AMOUNT OF OFFSET a
OFFSET CIRCUIT
OFFSET CIRCUIT
AMOUNT OF OFFSET b
58
59
AMP FACTOR
AMPLIFIER
AMPLIFIER
AMP FACTOR
56
57
MAGNETISM DETECTION ELEMENT
MAGNETISM DETECTION ELEMENT
54
55

FIG. 28

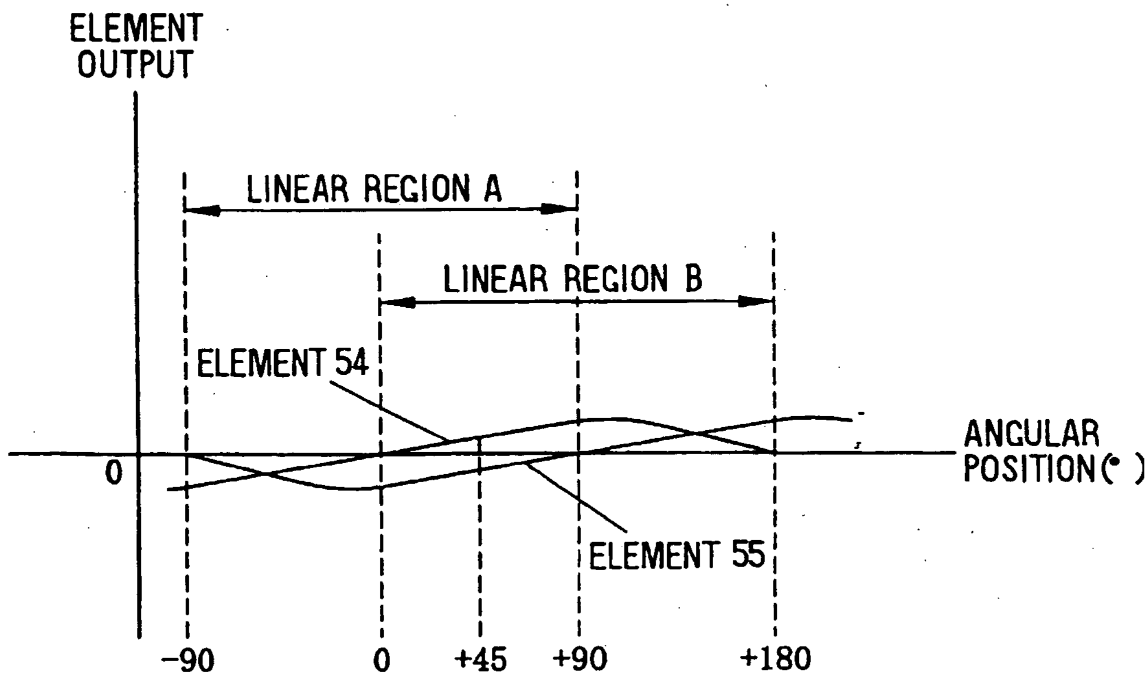

ELEMENT
OUTPUT
LINEAR REGION A
LINEAR REGION B
ELEMENT 54
0
ANGULAR
POSITION(°)
ELEMENT 55
-90
0
+45
+90
+180

FIG. 29

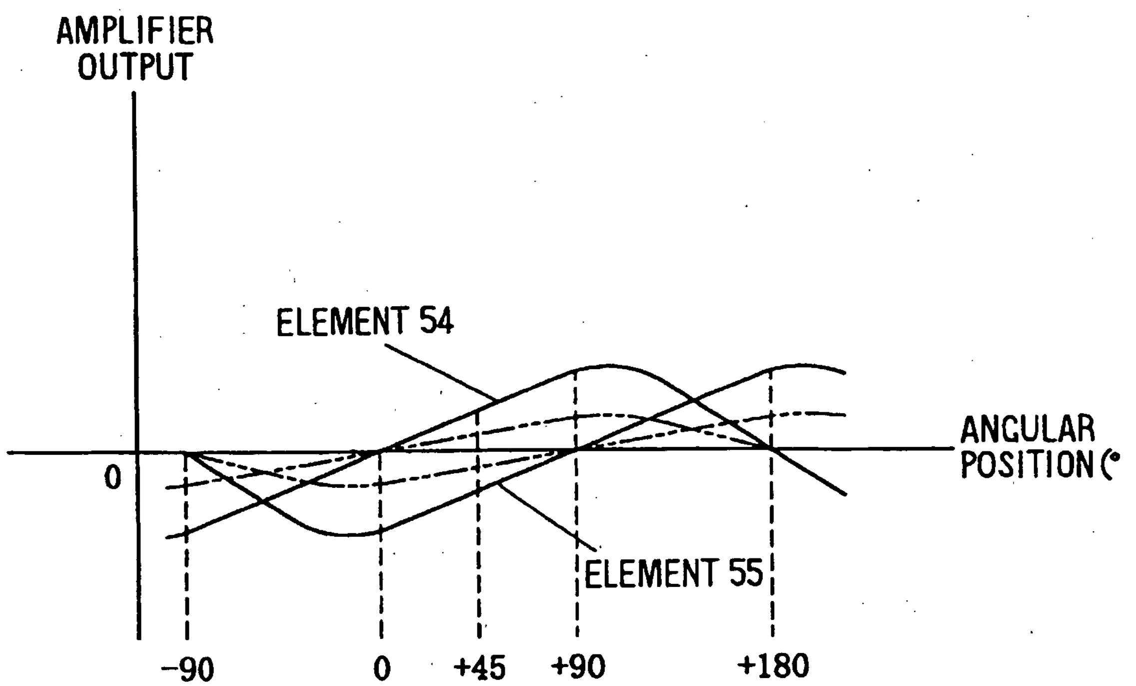
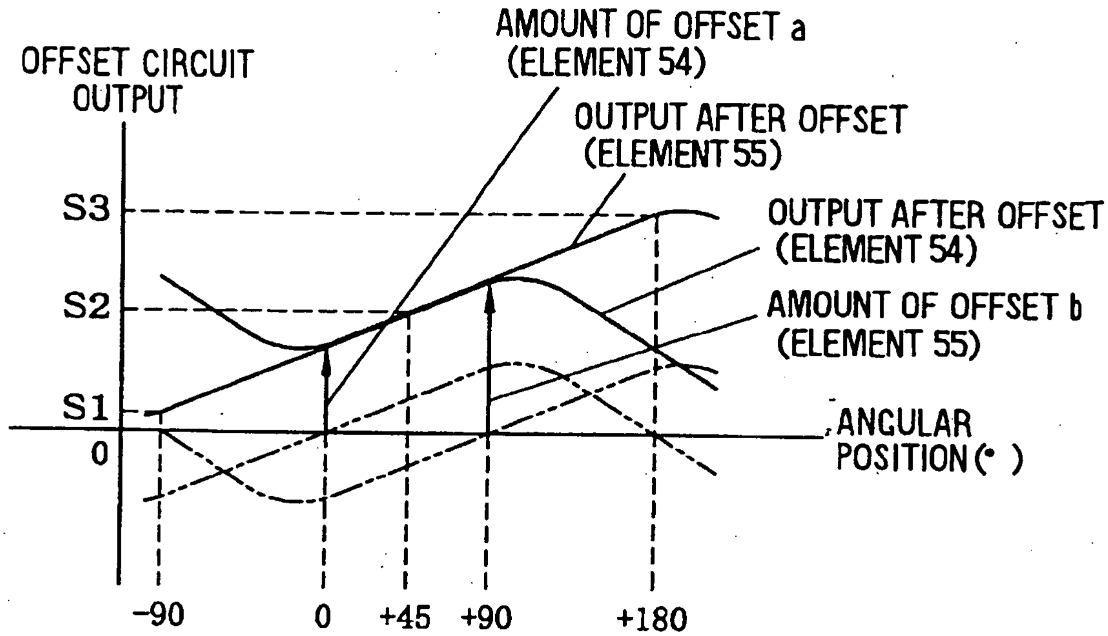
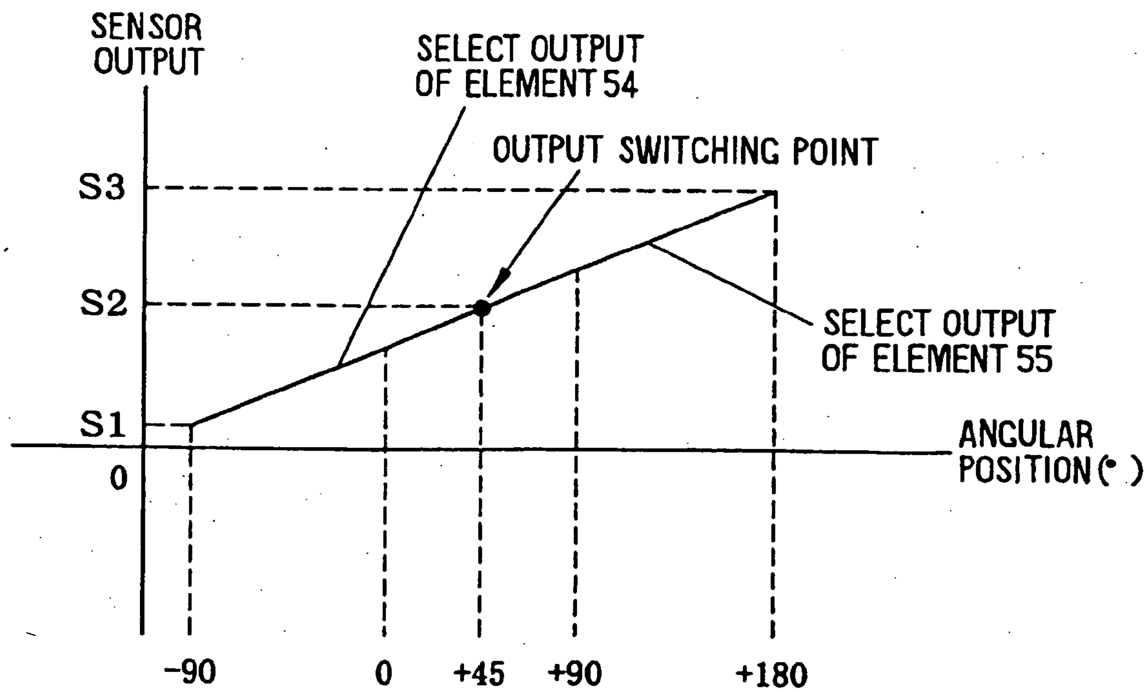

AMPLIFIER
OUTPUT
ELEMENT 54
0
ANGULAR
POSITION(°)
ELEMENT 55
-90
0
+45
+90
+180

FIG. 30



OFFSET CIRCUIT OUTPUT
AMOUNT OF OFFSET a (ELEMENT 54)
OUTPUT AFTER OFFSET (ELEMENT 55)
OUTPUT AFTER OFFSET (ELEMENT 54)
AMOUNT OF OFFSET b (ELEMENT 55)
S3
S2
S1
0
ANGULAR POSITION (°)
-90
0
+45
+90
+180

FIG. 31



SENSOR OUTPUT
SELECT OUTPUT OF ELEMENT 54
OUTPUT SWITCHING POINT
S3
S2
S1
0
SELECT OUTPUT OF ELEMENT 55
ANGULAR POSITION (°)
-90
0
+45
+90
+180

FIG. 32

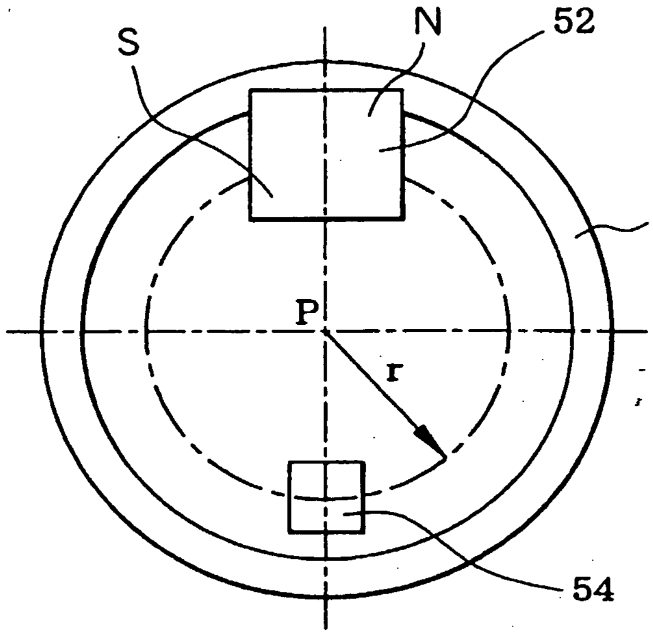

S
N
52
53
P
r
54

FIG. 33

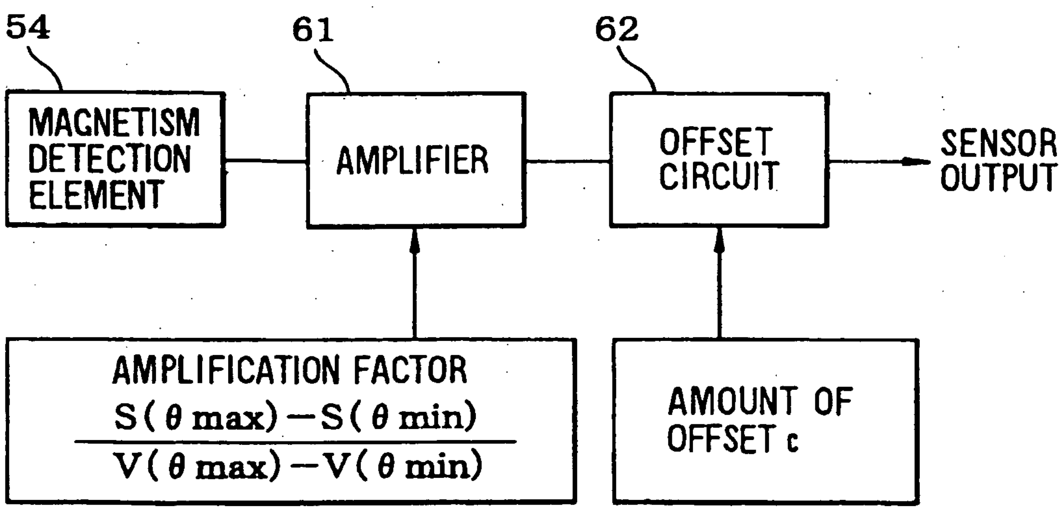

54
61
62
MAGNETISM DETECTION ELEMENT
AMPLIFIER
OFFSET CIRCUIT
SENSOR OUTPUT
AMPLIFICATION FACTOR
$\frac{S(\theta max)-S(\theta min)}{V(\theta max)-V(\theta min)}$
AMOUNT OF OFFSET c

FIG. 34

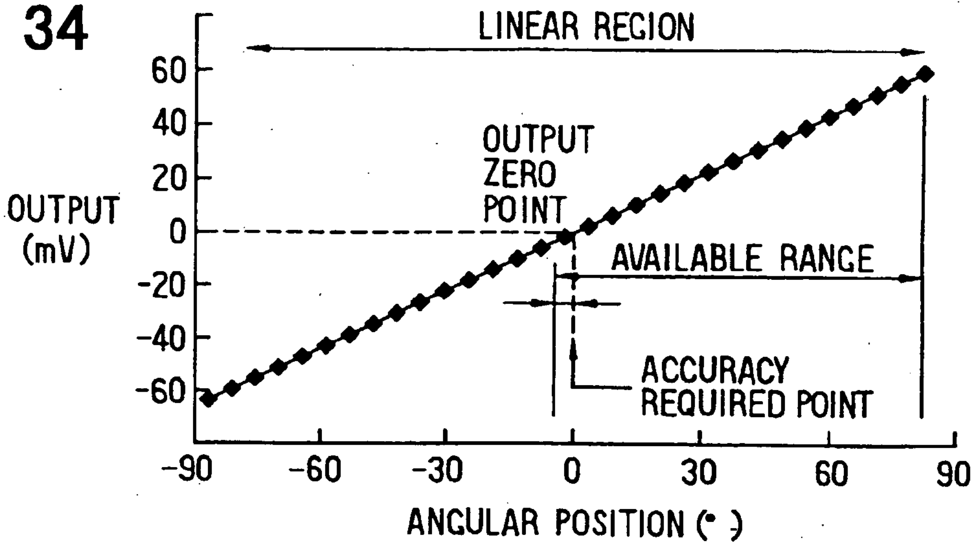


FIG. 35

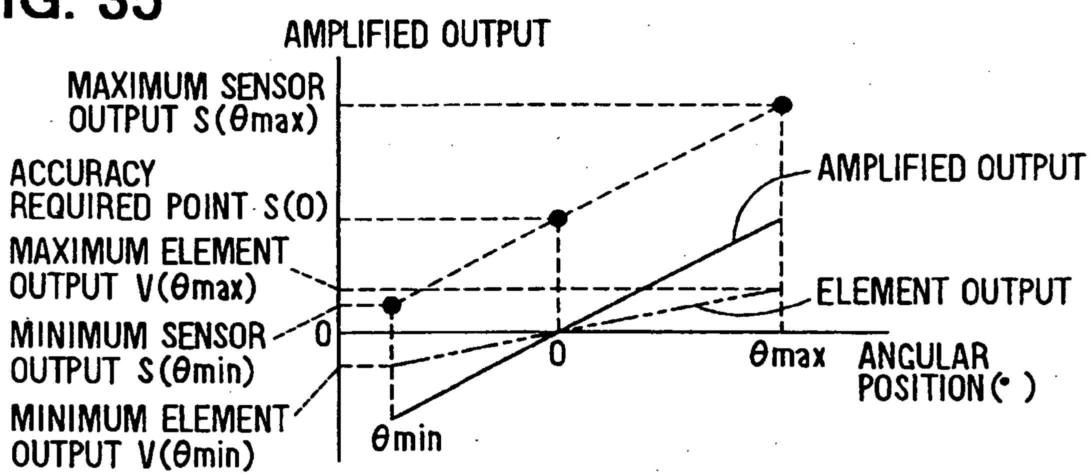
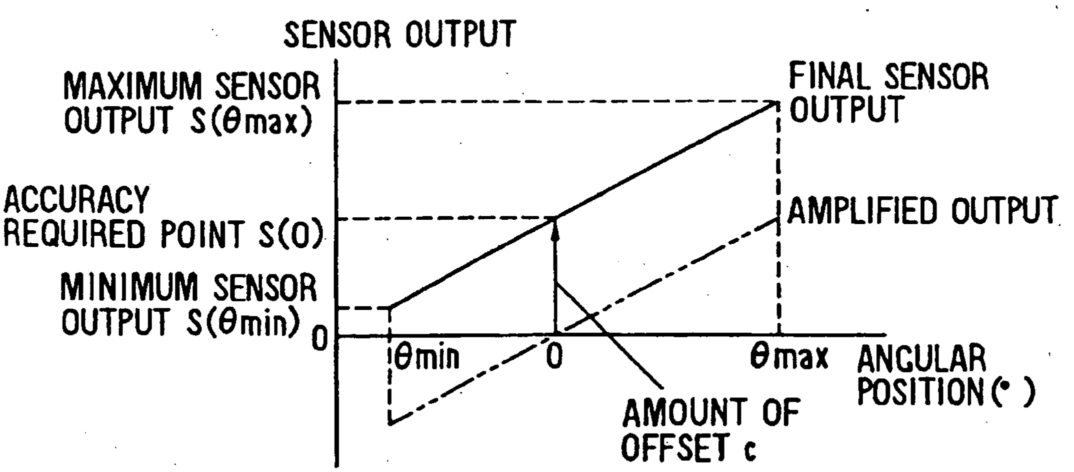


FIG. 36



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 11 5234

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 893 502 A (HITACHI) 16 January 1990 (1990-01-16) * column 6, line 42 - column 7, line 3; figure 10 *	1	G01B7/30 F02D11/10
X	US 5 544 000 A (NIPPONDENSO) 6 August 1996 (1996-08-06) * column 5, line 62 - line 65; figure 10 *	19	
A	US 5 789 917 A (MOVING MAGNET) 4 August 1998 (1998-08-04) * figures 1,5,6 *	1,2,15, 19	
A	US 4 392 375 A (NIPPONDENSO) 12 July 1983 (1983-07-12) * column 2, line 58 - column 3, line 13; figures 1,2 *	1,2,15, 19	
A	DE 44 00 616 A (VDO) 13 July 1995 (1995-07-13) * column 3, line 11; figures 1,3 *	12	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
G01B
F02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	29 September 2000	Mielke, W

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